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ANNUAL REPORT ON THE FEDERAL DEPARTMENT OF AGRICULTURAL RESEARCH FOR THE YEAR 1965-66

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ANNUAL REPORT

ON THE

FEDERAL DEPARTMENT OF AGRICULTURAL RESEARCH FOR THE YEAR 1965-66

REPORT BY THE DIRECTOR OF AGRICULTURAL RESEARCH

INTRODUCTION

Policy

The policy of the Federal Department of Agricultural Research is to raise the productivity of some of the major food crops of Nigeria through research into the improvement of the planting materials, the establishment of better methods of cultivation and harvesting, the development of better method of conservation of the soil and the nutrition of the plant and the control of plant diseases and pests. The Departmental research programmes reflected these objectives which were vigorously pursued to the limit of the available staff and research facilities.

Staff

On the face value, it would appear that there was a decline in the staff position. For example, in 1964-65, 89.6 per cent of the junior establishments and 69 per cent of the senior, were filled, as against 86.7 per cent and 51.6 per cent respectively for the year 1965-66. This decline is also reflected in the number of scientists which fell from thirty to twenty-four. The cause of this fall is not far to seek. The Department lost a number of its Research Officers to better bidders, like the Universities and other research organisations. It is a healthy but painful competition.

On the other hand, this seeming decline in percentage of staff employed to staff on establishment must be viewed along with the corresponding increase in the overall establishment for the year 1965/66. For example, there were 54 administrative and professional posts, 1965/66 as against 40 in the previous year. Similarly, in the executive, technical and administrative cadres, the establishment increased from 57 to 62 and 107 to 128 respectively. This increase in establishments which could not be followed up 'pari passu' with recruitment, has led to the apparent fall in percentages.

During the course of the year under review, the following officers who joined the staff of the Department were warmly received:

Mr F. O. Ajayi, Higher Executive Officer,
Mr A. Lewis, Technical Officer,
Mr St. Matthew-Daniel, Technical Officer,
Mr L. N. Ashikodi, Executive Officer,
Mr I. A. Dada, Assistant Executive Officer,

However, the Department regrets the loss by resignation, of Dr (Mrs) Mabadeje, a senior Research Officer, Mycologist; Dr N. Okafor, Dr E. N. Ugochukwu, Dr M. Nwagwu, Dr Anya, Mr A. A. Agboola, all Research Officers; and Mr A. I. Appah, Technical Officer.

The authorised establishments of the Department for 1965-1966, and an analysis of the progress in recruitment, Nigerianisation and in-service training, is given in Appendix I.

REVIEW OF RESEARCH

Maize

Maize breeders have continued their research for new maize germplasm among several hundred local and introduced varieties to breed improved varieties resistant to rust, leaf blight and lodging and 130 varieties showed a fair degree of disease resistance. The process of isolating desirable inbreds from adapted and acceptable maize varieties was carried a stage further by selecting 1162 lines from four white dent and six white floury varieties at Ibadan and 720 Lines from four yellow varieties and six dent varieties at Mokwa. Twenty-three inbreds out of 110 tested for their combining ability appreciably outyielded the highest yielding open-pollinated variety. It was shown that maize yields can be considerably increased by selection within crosses of dent and floury varieties showing the best combining ability and cross between a local floury variety, Lagos White, and an introduced dent variety, Eafro 231, gave the most promising results. Our maize synthetic variety NS-5 gave the best yields at Mokwa and Samaru in trials of 25 varieties.

Cowpeas

Among 25 day-neutral varieties, Dixie Lee Queen and Paraguay-18 gave the best yields at Ibadan and Samaru, and variety C5715-B, was found the best for late planting among 25 shortday varieties. Grain Legume breeder continued his efforts to purify and classify 800 cowpea cultivars collected and maintained by Nigerian Grain Legumes Gene Bank at Samaru. Plant Physiologist in his experiments on photoperiodism in cowpeas has shown that agromorphological characters such as plant habit, branching, flowering and fruit set of the same variety can be different under 10½, 11, 12 and 13-hour day-length and has redefined prostrate and climbing habits in cowpeas.

Sugar Cane

Heteronychus spp. and stem-borers are the major pests of sugar cane and research on biology, extent of damage has shown that *Heteronychus* spp. cause damage from April to June and during September to October. Three general of *Noctuidae* frequently damage sugar-cane and cause dead heart. The important being *Sesamia* spp. and *Eldana* sp. which are found throughout the year. *Chilotrea* spp. are mainly found during the rainy season.

Yams

Work on the biology and control of *Heteroligus* spp. damaging yams continued. *Heteroligus appius*, which is second in importance to yam has a similar life history as that of *H. meles*. The breeding of this beetle takes place in the marshy areas but the period of flight to the breeding areas is not so well defined as in *H. meles*. The larva of *H. appius* agrees in essential characters with that of *H. meles*, but can be differentiated on the basis of colour of head capsule, setae on frons, shape of spiracles and setae on raster. Control trials against yam beetle showed that Aldrin 2.5% dust applied to the planting holes is better than other methods of application; the earlier application was significantly better than late.

Rice

Rice borers are the main limiting problem on rice. *Diopsis sp.* attack rice in the nursery whereas *Noctuid* and *Pyralid* moths attack rice in the field. The main species attacking rice in the field are *Scirpophaga sp.*, *Hypstropha subcostella*, *Chilo* sps., *Maliarpha separatella* and some of these can cause losses up to 50 per cent. It was found that the attack in the field increases with the age of the crop. Kav. 12 variety was found to have 1.6 per cent damage at 9 weeks after seedling which rose to 57.6 per cent at 27th week. Stem borers seem to pass through the dry season in the rice stubble.

Citrus

The work on purple scale of citrus was intensified at Umudike and Nkwelle in Eastern Nigeria and control trials with Malathion 40 E.C., D.D.T. 25 E.C. and Rogor 40 E.C. sprayed either alone or in combination with an oil showed that Malathion 40 E.C. when sprayed with oil or alone gave above 90 per cent mortality of this pest. Life history studies show that the time of development from crawler to egg producing stage on rough lemon is longer than on sweet orange.

Seed Health Testing

Since the beginning of the seed health testing in 1964, the programme has been greatly expanded. During the year, nearly 1000 samples passed through the seed testing laboratory. Two hundred and fifty-five samples were from the 1965 rice crop as part of the rice multiplication scheme and studies on the distribution of rice seed-borne pathogens. A large number of samples of seed for export and ones which had been imported were tested. The division co-operated with the I.S.T.A. Plant Disease Committee in the international comparative testing programme.

The research on rice blast disease was mainly confined to the study of varietal resistance and pathogenicity of the fungus.

The research programme into the virus diseases of cowpea commenced in 1958 has been completed. Since 1958, nine viruses and virus strains have been isolated, and during the year, studies were completed on the seed-borne diseases. Methods have been devised for the screening of cowpea varieties for resistance to the two major diseases caused by cowpea yellow mosaic and cowpea mottle viruses. This aspect of the work will be continued as part of the selection programme of cowpeas.

During the year, a new programme of research into cassava mosaic virus disease was begun in cooperation with Dr J. G. Berbee of the Faculty of Agriculture, University of Ife. Initially, the work has included the attempted isolation of strains of the virus from the disease complex.

G. E. O. Okiy,
Director of Agricultural Research

REPORT ON THE MAIZE AND LEGUME BREEDING DIVISION

Maize Breeding

The maize breeding programmes continued to be devoted to the production of high yielding, acceptable multivarietal synthetics, suitably adapted to a wide range of climatic variation in the forest zone of Southern Nigeria and the savannah zone of Northern Nigeria. The forest zone programme was based upon Ibadan and Umudike; the savannah zone programme on Mokwa and Samaru.

Type Collection

Three hundred and fifty-four introduced and local maize varieties from the type collection were planted at Ibadan in early season for selecting material to breed improved synthetic varieties suited to different agro-climatic zones. The combined reaction of these types to rust (*P. polysora*) and southern leaf blight (H. madydis), the two most serious diseases of maize in Nigeria, at the time of tasseling (first week of July) is given in Table I.

TABLE I

NO. OF MAIZE VARIETIES SHOWING FIELD REACTION TO RUST AND LEAF BLIGHT, IBADAN, 1965

Leaf blight class	*Rust Class*					*Total*	*Percentage of Total*
	0	1	2	3	4		
0	1	—	—	—	1	2	0.6
1	—	45	49	55	82	231	65.3
2	—	14	21	14	33	82	23.1
3	—	9	3	7	9	28	7.9
4	—	—	1	4	6	11	3.1
Total	1	68	74	80	131	354	
Percentage of Total	0.3	19.2	20.9	22.6	37.0		

N.B.: 0 = complete resistance, 4 = complete susceptibility

It is clear from the table that the germplasm had a much higher degree of resistance or tolerance to leaf blight than to rust. One hundred and thirty varieties—36.8 per cent of the total—showed reasonable resistance to both diseases. Eafro P.64.26, a new introduction of Columbian origin, was the only immune variety. Thirty-nine out of 45 varieties with class one reaction to rust originated in the central America and only five originated in West Africa. This indicated a scarcity of rust resistance germplasm in Nigerian varieties.

Production of Inbred Lines and Top Crosses

At Ibadan, the selection of advanced generation inbreds from promising and acceptable open-pollinated varieties was continued with a view to producing topcrosses with three testers (Lagos White, Eafro 231, Sicaragua) for testing their general combining ability and developing high yielding synthetic varieties. A total of 1162 inbreds from four white dent varieties (Eafro 231, Diacol V. 153, Sicaragua, Mexico 5) and six white floury varieties (Lagos White, Ugep White, Akwete White, Ikom White, Bende White, Bende Local) were selected and 301 topcrosses with Lagos White, 211 with Eafro 231 and 166 with Sicaragua were produced.

At Mokwa, seven hundred and twenty-two S1 inbreds from four yellow fling varieties (Eafro 231, Eafro 269, Eafro 271, Bida yellow) and six white varieties (H.503, H.507, K3, K44, K50, Bida White) were also selected for the savannah zone areas at Mokwa (Northern Nigeria).

A recycling programme in the yellow synthetic variety NS-1 was initiated at Ibadan in order to improve its yield and resistance to lodging. Out of 313 plants selfed for height, ear placement, node number, etc. in a parental bulk, 136 plants were retained for further selection and topcrossing with the parental bulk.

Trials of Intervarietal Crosses

Fifteen intervarietal crosses between three dent varieties (Eafro 231, Diacol V. 153, Sicaragua) and five floury varieties (Bende White, Bende Local, Akwete White, Ugep White, Lagos White), and four crosses between Lagos White and other local floury varieties were compared with their open-pollinated parents at Ibadan, Mokwa and Umudike. The objective of these trials was to find out the best combining varieties for the development of high yielding multi-varietal floury synthetics adapted to a wider range of environmental conditions.

There was no significant difference between the overall combining ability of the same three dent varieties with the floury varieties at Ibadan, whereas Eafro 231 combined significantly better than Diacol V. 153 at Mokwa and the combining ability of Diacol V. 153 was superior to that of the other dent varieties at Umudike.

Among the floury varieties, Lagos White showed the best overall combining ability with the three dent varieties at all sites and the most promising varietal combination at Ibadan and Mokwa was between Lagos White and Eafro 231, and at Umudike, between Lagos White and Diacol V. 153. It will be seen in Table 2 that, although crosses between Lagos White and other floury varieties gave higher yields than open-pollinated varieties, crosses between dent and floury varieties were superior to the crosses among the floury varieties.

At Mokwa, the crosses of floury varieties with Eafro 231 were more susceptible to root lodging (42%) than those with Sicaragua (32%) and Diacol V. 153 (28%) and were also more susceptible than the open-pollinated parents (27%). The variety Ugep White was the most susceptible to root lodging (44%) and stalk lodging (8%) and its crosses with Eafro 231 showed the severest root lodging (56%). However, the root lodging of Lagos White (33%) and its cross with Eafro 231 (35%) was almost similar.

From these preliminary series of crosses, it is concluded that floury variety Lagos White has a wider range of general combining ability with Eafro 231, Sicaragua and Diacol V.153 than other floury varieties so far tested, and should form an essential component of any multi-varietal floury synthetic for the main maize growing areas of Nigeria.

TABLE 2

GRAIN YIELD (LBS/ACRE) OF SOME TOPCROSSES AND OPEN POLLINATED VARIETIES AT IBADAN AND MOKWA 1965

Floury Varieties	IBADAN			MOKWA		
	Eafro 231 Crosses	*Lagos White Crosses*	*Open pollinated varieties*	*Eafro 231 Crosses*	*Lagos White Crosses*	*Open-pollinated varieties*
Bende White ...	2692	2051	1972	3037	1785	1198
Bende Local ...	2444	1851	1440	3303	2275	1452
Akwete White ...	2468	2039	1543	2880	2051	1434
Ugep White ...	2445	1706	1688	3043	2632	1349
Lagos White ...	3346	—	1458	3527	—	1936
Mean	2681	1912	1620	3165	2186	1474
C.V. (%) ...		28.8			14.6	
L.S.D. (%) ...	N.S.	762	N.S.	N.S.	419	N.S.

Trials of Topcrosses

In order to select the best combining inbred lines for the production of high yielding maize synthetics for the forest zone, 62 top crosses between S4 inbreds of three dent varieties (Mexico 5, Sicaragua, Eafro 231) and a floury variety (Lagos White), and 58 topcrosses between S4 inbreds of three floury varieties (Lagos White, Akwete White, Ikom White) and a dent variety (Eafro 231) were compared with their respective parental varieties in two trials at Ibadan. In the first experiment, ten topcrosses of Mexico 5, three of Sicaragua and 19 of Eafro 231 inbred lines with Lagos White gave significantly higher yields than Lagos White but only one topcross of Sicaragua and seven of Eafro 231 were superior to their respective high yielding dent parents and none of Mexico 5 topcross was better than Mexico 5 parent. In the second experiment almost all topcrossed floury inbred lines were superior to their respective floury parents but only two topcrosses of Ikom White, seven of Lagos White and 14 of Akwete White inbreds with Eafro 231 yielded appreciably higher than Eafro 231 parent.

Variety Trials

Two early (K2, Eafro 250), two medium late (Eafro 231, Diacol V. 153) and two late maturing varieties (Lagos White, NS-1) were compared in replicated trials at Ibadan, Mokwa and Umudike with a view to determining the association of some plant characters of these varieties with grain yield under different environments.

The early variety K2 and the late variety Lagos White gave significantly less yield than the best varieties at all sites (Table . . .). Although there was no significant difference between the medium duration varieties Eafro 231 and Diacol V. 153, the former was better suited to Ibadan and Mokwa than to Umudike. There was thus no general correlation between duration and yield.

Twenty-five varieties, including 18 with white and seven with yellow grain, were compared in replicated trials at Samaru and Mokwa. The object was to select suitable material for breeding improved varieties for savannah zone areas. The high fertilizer application at Samaru (3 tons F.Y.M., 200-lb. superphosphate, 450-lb. sulphate of ammonia per acre) gave higher overall mean grain yield (3825-lb/acre) than the normal doze (250-lb/superphosphate, 300-lb sulphate of ammonia per acre) at Mokwa (2282 lbs/acre), See Table III.

TABLE 3

YIELD COMPARISONS OF SIX MAIZE VARIETIES (LBS/ACRE)

Variety	*Ibadan*	*Mokwa*	*Umudike*
	(±318)	(±111)	(±185)
Eafro 231	4838	3043	3703
Diacol V.153	4439	2735	4163
NS-1	4305	2549	4123
Eafro 250	3880	2051	4179
Lagos White	2835	1918	3429
K2	1542	1414	2209
Mean	3640	2285	3634
C.V. (%)	21.7	12.1	16.1
Least significant difference (P=0.05)	925	324	540

The best yields of 3163 and 5645 lbs/acre at Mokwa and Samaru respectively were obtained from white floury synthetic variety NS-5 but, on the basis of both trials, it was not significantly better than Sicaragua or H. 507. The yellow synthetic variety NS-1 again did not do well at Mokwa (2092 lbs/acre) or at Samaru (2656 lbs/acre) and was significantly outyielded by three yellow varieties, Eafro 237, Eafro 269 and Eafro 272. Two white synthetic varieties, NS-4 and NS-5, were less susceptible to root lodging (below 25%) than NS-1 (over 50%). Although five early maturing introductions from Kansas (U.S.A.) were less susceptible to lodging, their yields only ranged from 1385 to 1823 lbs/acre at Mokwa and from 2184 to 3442 lbs/acre at Samaru.

COWPEA BREEDING

Nigerian Grain Legume Gene Bank

The long term object of the N.G.L.G.B. accommodated at the Institute of Agricultural Research, Samaru, is the collection, purification, maintenance and classification of local and introduced cowpea varieties with a view to preserving valuable germplasm for use in crop improvement programme. A total of 799 cowpea cultivars were planted in the third week of June at Samaru. The observations on growth habit showed that 20 cultivars were erect, 370 semi-erect, 350 prostrate and 60 climbing (vining). Forty-three cultivars flowered under 30 days, 478 under 60 days, 499 under 80 days and 292 in over 80 days after planting. Thirty-five cultivars had short leaves (up to 4.0") and 144 had long leaves (over 5.0") whereas the leaves were narrow (under 2.0") in six cultivars and broad (over 3.0") in 304 cultivars.

Cowpea Inheritance Studies

Observations on the F1 generation of three hybrids between four cowpea varieties (Acq. No. 1, 157, 167 and 226) indicated that climbing plant habit was dominant to the semi-erect or erect habit and that erect habit was recessive to semi-erect habit. Purple pod colour appeared to be dominant to green whereas F1 stem colour was intermediate (purplish green) between purple and green.

Photoperiodism in cowpeas

In order to elucidate the effects of daylength on morphological characters of cowpeas, three contrasting varieties (Buma, Adzuki, Paraguay-2) were compared at 10½, 11, 12 and 13-hour daylengths in a replicated pot experiment in the greenhouse over a period of 2½ months.

Buma was an erect and dwarf plant in short day-lengths (up to 12 hours) but a long and prostrate plant in longdays (13 hours). Four weeks of shortdays produced maximum dwarfing and three weeks of longdays produced complete prostration of plants. No flower buds were formed on plants which stayed three weeks or longer in longdays whereas bud formation, flower opening and maturity were normal in shortdays or when plants stayed only one week in longdays.

Variety Adzuki was a semi-erect plant in 10% and 12 hours and a climber in 11 and 13-hour daylengths which also tended to keep the plant in the vegetative phase. Flower opening was profuse and regular in 10% and 12 hours.

The variety Paraguay-2 was a climber, late flowering and maturing under all photoperiodic treatments.

From the results of the experiment a prostrate plant can be defined as the one which forms long auxiliary branches in the first three nodes and a climbing plant is the one which does not bear vigorous auxiliary branches in its proximal nodes and has its longest auxiliary branches occurring distal to node 7. It was shown that plant habit and flowering in some varieties were affected by daylength and these characters could not be used as a basis of agro-botanical classification without reference to daylengths under which photoperiodically sensitive varieties were grown.

Cowpea Variety Trials

Day-neutral varieties. Twenty-five day-neutral cowpea varieties were compared at Samaru and Ibadan in trials planted on 21st June and 17th September, and harvested in the first week of October and the third week of November respectively. The crop was sprayed twice with Didigam at half gallon in 20 gallons of water per acre. The yield of dried beans ranged from 202 to 1613 lbs per acre at Samaru and from 468 to 772 lbs per acre at Ibadan. All the varieties were erect or semi-erect in habit. Dixie Lee Queen and Paraguar-18 gave the top yields at Samaru and Ibadan respectively but were not significantly superior to New Era-A1, Jobo Kowo, Ayul Grand, Kwara Kwoi-C and Mississippi-51 at either site.

Short-day Varieties. A trial consisting of 25 short-day cowpea varieties was planted at Ibadan on 24th September and harvested at the end of November. The yield of dried beans ranged from 299 to 764 lbs per acre. The variety C5715-B gave the best yield but it was only significantly superior to six out of the 24 varieties.

Cowpea Acceptability Tests

An investigation was carried out at Samaru on the acceptability of four cowpea samples with rough, cracked, wrinkled and smooth seed coat texture for the preparation of *moin-moin* and *akara balls*. All 50 persons in the testing panel selected the rough seed coat sample on the basis of the ease of removing the seed coat, though 39 persons also claimed that this particular sample tasted better than others.

The same four samples were also immersed in cold water at 20°C constant temperature for one hour. The percentages of seed coat removable afterwards were 97.2, 94.4 and 33.3 in the varieties with rough, cracked and wrinkled seed coat textures respectively and only 4.4 in the variety with smooth seed coat. In another experiment the seed coat of the varieties with rough and cracked seed coat textures could be removed after soaking for about 15 minutes, which the wrinkled seed coat types required two hours soaking before complete removal was possible. Only 40 per cent of the smooth seed coat could be removed even after being soaked for three hours.

REPORT ON THE PLANT PATHOLOGY DIVISION

MYCOLOGY

Rice Blast Disease

Varietal Resistance and Race Typing. Varieties Tjina, Lead 35, Mali Ong, MLY-C × VI 203, C7450 and C7472 were found resistant to blast disease, *Pyricularia oryzae*, in two nursery trials of 90 varieties made at Ibadan. The latter two varieties are white grained varieties of the indigenous species *O. glaberrima*. The pathogenicity of two isolates of Pyricularia from Western Nigeria and one from Eastern Nigeria was tested using the above resistant varieties. Mali Ong was resistant to the isolate from Eastern Nigeria and one of the isolates from Western Nigeria, but was moderately susceptible to the isolate from Ijebu-Ode. The other five varieties were resistant to all three of the Nigerian blast isolates.

Chemical control. In nursery spraying trials at Ibadan, Blasticidin (blasticidin-S-benzylaminobenesene sulphate) was the most effective chemical for the control of blast disease. Blasticidin prevented the stunting effect caused by severe blast attack, although it did not completely prevent the development of *Pyricularia* leafspots. Dithane M-45 (co-ordination product of zinc ions and manganese ethylene bisdithiocarbamate) was not as effective as Blasticidin, but significantly better than zineb (zinc ethylene bisdithiocarbamate) and DuTer (triphenyl tin hydroxide) which did not give any control. The control achieved with Blasticidin and Dithane M-45 in 1964 was thus confirmed.

Rice Seed Health Testing

Two hundred and fifty-five seed samples of the 1965 rice crop from different parts of Nigeria were tested for seed-borne fungi. The incidences of the two most important fungi *Pyricularia oryzae* and *Helminthosporium oryzae* are given in Table IV.

TABLE 4

INCIDENCE OF HELMINTHOSPORIUM ORYZAE AND PYRICULARIA ORYZAE IN SEED SAMPLES FROM THE 1965 RICE CROP

Region	*Number of samples*	*Helminthosporium*		*Pyricularia*	
		Number of samples infected	*Average % infection of infected samples*	*Number of samples infected*	*Average % infection of infected samples*
Western	81	65	21.0	25	1.3
Midwestern	25	19	10.2	3	1.7
Eastern	23	9	1.4	1	1.0
Northern	126	92	3.2	7	0.8
TOTAL	255	185		36	

Helminthosporium (brown spot) infection was highest in Western Nigeria. Twenty-four samples from Egba Division in Abeokuta Province, and eight samples from Ekiti and Owo Divisions in Ondo Province had over 20 per cent infected seed. These samples were all of upland rice, and it can be concluded from the results that brown spot is a potential hazard only on the upland rice crop. From field experience, infection percentages of less than 15 per cent are considered relatively harmless, and therefore the disease is not important in the swamp rice crop grown in Northern and Eastern Nigeria.

Only low levels of *Pyricularia* infection were recorded in the samples from the 1965 crop. The highest percentage recorded was 3.5 per cent on a sample of upland rice from Western Nigeria.

Other Rice Diseases

Rhizoctonia solani, causing a basal sheath rot, was observed on several upland rice plantings, and was common on the permanent rice plot at Moor Plantation, Ibadan.

Green or false smut, *Ustilaginoidea virens* was observed on a farm near Ilesha, Western Nigeria, and up to one per cent infection was recorded.

Maize Diseases

Leaf blight. Nearly 400 varieties were screened for resistance to *Cochliobolus heterostrophus* in 1965. The plants were sprayed with a suspension of the fungus when 4-5 weeks old and scored for infection about 4 weeks later. Only nineteen varieties did not develop any *Cochliobolus lesions*.

VIROLOGY

Cowpea Mottle Virus

An isolate of this virus from bambarra groundnut, *Voandzeia subterranea*, was carried in the seed of *V. subterranea* but not in the seed of cowpea. Both the previously reported isolate of this virus from cowpea and the *Voandzeia* isolate resisted heating to 50°C, but differed markedly in their dilution end-points. The cowpea isolate withstood dilution to 1/250,000 and the *Voandzeia* isolate to 1/1000. An antiserum prepared to the cowpea isolate had recipitation end-points of 1/512 and 1/32 against the cowpea and *Voandzeia* isolates respectively.

Seed-borne Viruses of Cowpeas

The virus isolated from cowpea variety Shendam A growing at Ilorin in 1961 (Rep. Agric. Res. Dept. Nigeria, 1963–64) has been called cowpea green mottle virus. The virus was partially purified by extraction in neutral phosphate buffer and chloroform/butanol mixture followed by differential centrifugation. This method resulted in loss of virus infectivity, through virus purified in this way was used to prepare antiserum. The antiserum has a precipitation end-point of 1/256, and the flocculent type of precipitate suggested that the virus has rod-shaped particules.

The seed-borne virus isolated from cowpea variety Paraguay 6 in 1962 (Rep. Agric. Res. Dep. Nigeria, 1963-64) and a second virus isolated from the same cowpea variety in 1965 were shown to be strains of cucumber mosaic virus, and called cowpea strains 1 (CMV-CS1) and cowpea strain 2 (CMV-CS2). Both strains have wide host ranges: CMV-CS1 infected 26 leguminous and 21 non-leguminous species, and CMV-CS2 28 leguminous and 19 non-leguminous species. Both strains had dilution and end-points of less than 1/20,000, withstood ageing at room temperature for 24 hours, and had low thermal inactivation points (CMV-CS1, 40°-45°C; CMV-CS2, 45°-50°C). They were transmitted by *Aphis craccivora* and *A. gossypii*, and their seed-transmission rated in cowpea

varied from 0 to 7.9 per cent depending on the variety. The two strains protected against each other in reciprocal tests in cowpea and cucumber. Antiserum prepared to cowpea strain 1 had a precipitation end-point of 1/64 with its homologous antigen and cowpea strain 2. Both strains reacted in gel-diffusion tests with antiserum to cucumber mosaic virus strain 14 from the U.S.A.

Virus Resistance in Cowpeas

The primary leaves of plants of 79 varieties of cowpea (*Vigna sinensis*) gave either no reaction or developed necrotic or chlorotic lesions when inoculated with the original or Igporin isolate of cowpea yellow mosaic virus. Two types of necrotic lesions, varying in size and appearance, were observed. Plants that gave no reaction were immune from infection with the virus; those that developed necrotic lesions were resistant; those that developed chlorotic lesions were susceptible. Thirty-two of the varieties were also inoculated with Igporin isolate of the virus, and although the reactions in seven varieties differed from those caused by the original isolate, the relationship between the local reactions and immunity from or resistance to infection was similar. (Abstract from Phytopathology, 55, 923-925, 1965).

Sugar cane mosaic virus

Mosaic disease was recorded for the first time in Nigeria in the sugar cane collection plots at Moor Plantation. Leaf symptoms were seen in varieties Co. 349, Co. 622, Co. 740, Co. 991 and J. 247B. The symptoms in all the varieties was of the green or mild mosaic type. The virus was transmitted by sap-inoculation from Co. 622 to sorghum and six maize varieties.

PLANT DISEASE SURVEY

The following diseases were recorded for the first time in Nigeria.

Sugar cane. Red stripe disease caused by *Pseudomonas rubrilineans* (Lee et al.) *Stapp.* was recorded on variety B. 4362 at Bacita, Ilorin Province. Identical symptoms were seen on Co. 419, B. 46364 and B. 37161, with the latter variety also showing top rot.

Benniseed. Leaf curl disease affected approximately eight acres of the crop at the Institute of Agricultural Research Sub-station, Mokwa. The disease was also reported from Benue and Kabba Provinces.

Guar. Web-blight caused by *Rhizoctonia microsclerotia* was observed in the collection plots at Moor Plantation.

Rice. Chaetoseptoria spp. on rice leaves collected at Wasimi, Abeokuta Province. No species of *Chaetoseptoria* had previously been recorded on rice.

Coffee. (*C. arabica*). *Asteridiella naucleae* (Boedijn) Hansf. var. *libericae* Hansf. on coffee leaves at Moor Plantation, Ibadan.

REPORT ON THE ENTOMOLOGY DIVISION

YAM PESTS

Biology of Heteroligus spp.

Field population. Studies on the biology of *Heteroligus meles* and *H. appius* continued with the sampling of the field population in the yam beetle breeding areas along the River Niger near Onitsha. Third stage larvae were collected from April until June, whereas only pupae and adult were collected during July. This indicates that the emergence of the adults takes place over a period of four to four and a half months. (See Ann. Rep. Dept. Ag. Res. 1964/65.) In the laboratory at Ibadan, the third stage larvae were common in rearing cultures up till the end of July and they completed their development by the end of August. The data on the population studies are given in Table V.

TABLE 5

HETEROLIGUS SPP. POPULATIONS AT ONITSHA 1965

Months	*No. of Samples taken*	*Population*			
		Larvae	*Pre-pupae*	*Pupae*	*Adults*
April	333	203	1	—	—
May	348	1461	41	89	48
June	376	52	18	72	86
July	300	—	—	15	20
August	300	—	—	—	—
September ...	300	—	—	—	—

Migration. Work also continued on the yam beetle migrations, which were studied both at Onitsha and Ogoni by operatiing light traps. It was found that the post teneral flight commenced in April after the rains had set in. At Bori Ogoni the first flight was observed on April 4, 1965; at Onitsha it was on May 17, 1965. These flights continued over a period of five months. Many more bettles were observed flying at Onitsha than at Bori Ogoni.

Biology of Heteroligus Appius

Heteroligus appius causes damage to yams in many localities in Nigeria. The adult beetles feed on the newly planted yam setts from April to June and then on the developing tuber from late July until the harvest and make characteristic holes on the tuber. The beetles leave the yam fields from late October to December, after the harvest of the yam crop, and move to the breeding areas for oviposition.

Flight. *Heteroligus* spp. in Nigeria usually have one generation with two nocturnal flight periods per year. The first or post-teneral flight of *H. appius* occurs during the period of April to early June when newly emerged beetles migrate to the yam fields. *H. appius* adults do not seem to be so attracted to light traps as other Dynastid beetles.

During June and July beetles are usually at a depth of 12 to 18 inches, resting, and there is very little activity in the field although occasional adults are attracted to light traps. During the same period, in the laboratory at Ibadan, the beetles did not feed and remained at the bottom of the breeding jar. During late July the beetles migrate up in the

heap and start feeding on the developing tuber. This species do not seem to have a definite pre-reproductive flight period. A few specimens have been collected at the light trap as early as October and a few as late as March and the beetles collected during March had mature ovaries and readily started depositing eggs.

Oviposition. Oviposition in the laboratory started on November 15, 1965 and finished on April 4, 1966, and during this period two females laid 93 eggs. The oviposition was irregular as on certain days no egg was laid, whereas on the other days one to ten eggs were laid. Most of the eggs were fertile and of the 93 eggs laid, 73 hatched, in the laboratory.

The Egg. The eggs are similar to those of H. meles in shape but are comparatively smaller in size and measure 2.2-2.6 mm in length and 1.8-2.0 mm in breadth. The egg during incubation absorb moisture and becomes almost round at hatching. The incubation period of the egg was studied at temperatures of 75°F±2°, 77°F ± 1° and 80°F ± 2°. It was found that at the lower temperature of 75° ± 2° the mean incubation period was 29.3 days whereas at a temperature of 80°F ± 2° the mean incubation period was 18.9 days. Table 6 shows the duration of incubation period at three temperatures.

TABLE 6

DURATION OF INCUBATION OF H. APPIUS EGGS AT THREE TEMPERATURES

	Temperature		
	70°F ± 2°	*77°F ± 1°*	*80°F ± 2°*
Incubation period ...	25 — 36		
(Range)	25 — 36	23 — 31	26 — 21
(Mean)	29.3 ± .31	24.9 ± .83	18. 9 ± .40
No. Studied	124	47	78

The larva. The larval development of H. appius was studied at temperatures of 75°F ± 2° and 80°F ± 2° and it was found that the larva undergoes three moults. At 75°F the first moult was observed after 23 to 25 days, the second stage lasted for 13 to 18 days and the third stage, which was the longest, lasted for 35 days. This is the most active stage in the larval life and during this period it fed actively. At a lower temperature of 75°F all the stages in the life history were comparatively longer, the first stage lasting for 38-40 days, the second stage for 20-24 days and the third larval stage lasted from 52 to 60 days.

Near pupation the larvae became inactive and entered into prepupal stage; this lasted for 4 to 6 days at 80°F and the pupal stage was observed to last for from 15 to 18 days at the same temperature.

The data on duration of the various stages at two temperatures are given in Table 7.

TABLE 7

H. APPIUS DURATION OF VARIOUS LARVAL AND PUPAL STAGES AT TWO TEMPERATURES

Stage	*Temperature*			
	75°F ± 2°		80°F ± 2°	
	Range	*Mean*	*Range*	*Mean*
1st stage larva	38—40	39.0 ±.37	23—25	24.3±.35
2nd stage larva	20—24	23.0 ±.52	13—18	14.6±.73
3rd stage larva	52—60	57.6 ±.47	35—45	36.6±.87
Prepupal stage	8—13	11.0 ±.72	4—6	5.5±.23
Pupal stage	20—26	21.5 ±.29	15—18	16.0±.36

Insecticidal control

A yam beetle control trial designed to test the comparative effectiveness of Aldrin 2.5% dust, B.H.C. 0.5% dust and Telodrin 0.5% dust applied (*a*) as a sett dressing, (*b*) to the planting holes, and (*c*) in a ring around the plant, were carried out at Bori Ogoni in 1965. The results indicated that Aldrin 2.5% dust was significantly better than B.H.C. dust in all methods of applications. The method involving application of the dust to the planting hole was significantly better than the other methods of application. The data are given in Table 8.

TABLE 8

MEAN PERCENTAGE OF CLEAN STAND ATTACKED

Insecticides	*Methods of application*			*Mean*
	I to setts ± 4.38	*II to planting hole*	*III in a ring*	
Aldrin	75.2	80.8	67.7	74.6
Telodrin	67.4	80.1	61.9	69.8
B.H.C.	65.7	50.6	54.9	56.6
Mean	69.4	70.5	61.0	64.7

Control = 59.1; L.S.D. 5% = 12.7, 1% = 17.1

In another trial, carried out at Ogoni, to test the effectiveness of the three selected insecticidal dusts applied at different times (from March to July) during the crop season, it was found that the Aldrin 2.5% dust applied in March gave the highest yield of clean tubers and fewer plants were attacked. The data are presented in Table 9.

TABLE 9
WEIGHT OF CLEAN TUBERS (IN LBS) HARVESTED PER 100 PLANTS

Insecticides	*Time of Application*					*Mean*
	March	*April*	*May*	*June*	*July*	
Aldrin	187.8	142.2	146.2	140.6	112.0	145.7
BHC	139.8	151.0	118.6	135.4	104.0	129.7
Telodrin	160.2	144.6	143.6	131.6	95.4	135.1
Mean	162.6	145.9	136.1	135.9	103.8	136.8
L.S.D.	5%	10.6	13.7	24.0	NS	
	1%	14.0	18.0	31.4		

The results indicate that:

Aldrin 2.5% dust applied on March 5 gave the highest yield of clean tubers and fewer plants were attached.

Telodrin dust applied on June 3 gave the highest control on stand basis but the yield of clean tubers was about the same as with other insecticides.

B.H.C. dust proved inferior in controlling yam beetle damage in comparison with Aldrin 2.5% and Telodrin 0.5% dust. However, B.H.C. seems to increase yield which was significantly better than Telodrin.

Telodrin dust showed a depressing effect on yield.

SUGAR CANE PESTS

Biology of Heteronychus licas

Studies on the biology and ecology of *Heteronychus* spp. at Bacita and Ibadan continued. At Bacita in 1965, the adult population increased during April and May and caused many dead hearts. The adults during this period were found feeding on the sugar cane stem at the ground level and in certain cases were also collected at the depth of 3-4 inches. During June, fewer beetles were collected as by then the beetles had started migrating deep into the soil. No beetles were collected during July and August as the beetles by then had burrowed deeply in the soil and there was no activity in the field. The beetles again become active during September but very few were collected in the samples taken and due to low population the number of attacked stems was low. During this period, only three larvae were collected during December.

Parasites and predators. Very few parasites have so far been recorded on this beetle. A certain number of Carabaeid beetles have been found in the field and a few were found to feed on the larvae and adults of *Heteronychus* spp. Species of *Carabaeid* beetles, suspected to be predatory to *Heteronychus* larvae, which were collected around sugar cane stools at Bacita included *Ochryopus feisthameli*, *Scarites senegalensis Dej.*, *Scarites* spp. *Siagona mandibularis* Gur., *Siagona* spp., *Pheropsophus parallelus* Dej., *Drypta ruficollis* Dej., *Melagonum explanatum* Bat., and *Hoplolenus obesus* Murr.

Mites were commonly found on the larvae and adults of *Heteronychus* but did not seem to cause any ill effect to the host.

Biology of sugar cane stem borers

The work on the population studies of stem borers continued during this period and it was observed that while *Sesamia* spp. and *Eldana* spp. larvae were collected throughout the year, the *Chilotrea* spp. larvae were found mainly during the rainy season and only few were collected during the dry season.

Sesamia spp. seem to have two peak seasons, the first peak being in July to August and the second during February and March. *Eldana* spp. also had two peaks, one in August and September and the other during January and February. *Chilotrea* spp. were more common during July and August. The data on larval stem borer population collected during this period are given in Table 10.

TABLE 10

STEM BORER LARVAL POPULATION ON SUGAR CANE AT BACITA

Month	No. examined	No. attacked	Larvae collected					
			Sesamia		Eldana		Chilotrea	
			L	P	L	P	L	P
April 1965	720	9	1	—	—	—	—	—
May	1762	759	177	—	24	—	8	—
June	3158	2840	589	—	19	—	12	—
July	4259	4184	544	5	8	—	26	—
August	3412	2743	507	21	11	2	24	3
September	4457	3199	835	7	15	1	10	—
October	2469	1672	201	8	36	1	1	5
November	1320	124	15	—	3	—	5	—
December	1320	43	9	—	6	—	2	—
January 1966	1165	296	36	—	53	—	3	—
February	1200	336	118	2	39	—	—	—
March	1380	277	115	3	12	—	—	—

Alternate hosts. Stem borer larvae were also collected from other cereal crops and grasses to determine the comparative population of these borer species in these alternate hosts around the sugar cane plantation. It was found that other cereal crops in Bacita area were attacked by *Coniesta* spp., but these species did not attack sugar cane and grasses. *Eldana* spp. and *Sesamia* spp. were also collected from cereal crops but in smaller numbers compared to *Coniesta* spp. *Grasses* actually supported a good population of *Sesamia* spp., but very rarely were any of the important species attacking sugar cane found.

Biology of the purple scale

The egg. Studies on the biology of the citrus purple scale insect continued during 1965, mainly at Umudike. Observations were made on monthly basis on the purple scale insect *Lepidosaphes heckii*, on leaves and fruits of sweet orange and grapefruit. These scales were examined to determine the number of eggs under each scale covering. The data are presented in Table 11.

TABLE 11

NUMBER OF EGGS FOUND BY EXAMINATION OF FEMALES OF L. BECHII ON GRAPEFRUIT AND SWEET ORANGE AT UMUDIKE

Date	*Total No. of female scales examined on*		*No. with eggs on*		*Range*		*Average No. of eggs/female with eggs*	
	Fruit	*Leaves*	*Fruit*	*Leaves*	*Fruit*	*Leaves*	*Fruit*	*Leaves*
1.1.66	60	80	43	40	25-77	20-23	48.2	33.8
16.2.66	216	220	81	57	34-63	22-56	44.8	32.8
16.3.66	90	90	45	53	31-60	20-52	46.8	32.1

It was observed that the purple scale insects found on the fruit were larger than those on the leaves and laid significantly more eggs than those on the leaves. This insect, on the fruit, laid 25-77 eggs with an average of 46.6 while on the leaves the number of eggs laid range from 20 to 63, with a mean of 32.9. The S. E. of the difference is 4.23 and the difference was significant (P=0.001).

Life cycle. Purple scales were reared on potted sweet orange and rough lemon seedlings. On sweet orange, the time required for development from crawler to egg producing stage was found to be 37.8 days at a temperature of 83.4°F$\pm$0.64° and humidity of 73.4$\pm$2.63 per cent, the males emerging in 30.8 days. On rough lemon, under the same conditions, the time for development was 36.3 days and males were obtained at 32 days. In both breeding experiments, males significantly out-numbered the females, (P=0.001).

Seasonal fluctuation. This observation is being carried out in a sweet orange orchard (Nigerian Green Orange) at Umudike. Counts of purple scale insects were made from samples of 200 leaves selected from ten trees, under observation, at fortnightly intervals. Twenty leaves were obtained from each tree, five leaves being selected at random from each of the quadrants of the tree. The leaves were put in plastic bags and taken to the laboratory for examination. The number of live and dead scales was determined under binocular microscope or hand lens; a scale insect was counted alive if body fluid was exuded when pressed with a mounting needle. The results obtained to date are presented in Table 12.

TABLE 12

PURPLE SCALE INSECT POPULATION AT UMUDIKE

Month	Number of Scales alive	Number dead by			Number of scales dead
		Fungus attack	Insect Parasite	Desiccation	
January 1966 ..	121	26	38	277	314
February 1966 ..	245	38	98	992	1,128
March 1966 ..	391	6	24	277	307

Insecticidal control

A series of insecticide trials were carried out at Umudike to test several insecticides alone and in combination with oil (Albolineum No. 2), so that the more promising ones could be selected for more intensive testing. The chemicals found showing promise in the preliminary trials were Malathion, DDT and Rogor, and these were selected and further tested at increased dosages. In all the trials randomized single-tree plots, replicated four times, were applied with a motorized pressure sprayer using $2\frac{1}{2}$ gallons of each insecticide to spray four trees to dripping point.

The final trial, using the three selected insecticides was carried out over about 0.4 acre of the Umudike citrus orchard. The results indicated that Malathion 40 E.C., either used alone or in combination with Albolineum, would kill more than 93 per cent of the scales.

RICE PESTS

Pest survey

During this period, work on rice pests continued at Ibadan and Badeggi and the following new insect pests were recorded from rice:

Lepidoptera

Syntomidae

Syntomus spp. (Cerbera L.)

Pyralidae

Maliarpha separatella Rag.
Rhinaphe vectigerella Har.
Sylepta balteata F.
Hypsotropha subcostella Hamps.
Adelpherupa flavescens Hamps.
Scirpophaga spp.
Nymphula stagnalis Zeller

Hemiptera

Cicadellidae

Extianus spp.
Nephotettix spp.
Hecalus spp.
Cicadella spp.

Aphididas

Hysteroneura setariae (Thomas)

Coleoptera

Meloidae

Cylindrothorax melanocephala L.

Pest population. Light trap collections were regularly made at the Rice Research Station (both upland and lowland sites) during this period to assess the comparative population of rice pests. In the upland collection it was found that *Sesamia* spp. and *Maliarpha* spp. were common only during the dry season, whereas the other species of borers were present throughout the year. *Nymphula stagnalis* was found from October to February.

Cylinderothorax melanocephala, which feeds on the rice head, was common only during October. In the lowland collection, *Chilo* spp. and *Scirophaga* spp. were very common during the rice crop season but the population decreased during the dry season.

Rice stem borers

Population fluctuation with ages of crop. During October to December 1965, samples were taken from the variety Kav. 12 at different periods of growth of the crop to assess the stem borer damage at these periods. It was found that the stem borer damage increases with the age of the crop. Nine-week old crop samples showed 1.6 per cent borer damage whereas 27-week old crop samples showed 57.6 per cent borer damage. The data on the number of tillers examined at different periods and the percentages of attack are given in Table 13.

TABLE 13

STEM BORER DAMAGE TO RICE AT DIFFERENT PERIODS

Age in week	*No. of tillers examined*	*No. of tillers bored*	*Percentage damage*
9	129	2	1.6
12	145.5	6.5	4.45
13	138	42	30.4
15	187	50.5	27.3
18	162.6	40	23.7
21	140.5	71	48.6
24	162.0	97	59.9
27	137	79	57.6

Population fluctuation during the dry season. Certain species of rice stem borers enter diapause during the dry season, whereas the other species move to the alternate host when rice stems are not available in the field. During March 1966, samples were taken to determine the population of rice stem borers in rice stubbles and grasses. It was found that *Hypsotropha* spp. and *Scirpophaga* spp. only were found in stubbles whereas *Chilo* spp. and *Maliarpha* spp. were found both in grasses and stubbles.

Insecticidal control

A trial control to test the effectiveness of two formulations of B.H.C., applied with the irrigation water, was carried out at Badeggi. Gamaline A and Agrocide were tested at rates of 3 lbs and 5 lbs per acre applied after the 8th and 15th weeks after seeding and at 2 lbs, 3 lbs and 5 lbs per acre applied on the 8th, 12th and 17th weeks after seeding. Samples were taken after the 7th, 11th and 15th weeks after seeding and it was found that both the formulations of B.H.C., applied at all these periods, reduced the stem borer attack significantly as compared to the control but there was no difference in the rice yield obtained.

REPORT ON THE CHEMISTRY DIVISION

CROP NUTRITION

Nutrient content of rice irrigation water

Samples of irrigation water for analysis were taken at monthly intervals in 1965 from the Duku Lade irrigation scheme, Pateggi (Ilorin Province) and the Edozhigi, Kupanko, Badeggi and Loguma (Katcha) irrigation schemes in Niger Province. In addition, for comparison, samples were also taken from six locations on the Sokoto River at Birnin Kebbi, from the Bende (Umuahia) irrigation scheme and from the tidal waters flooding the mangrove rice swamps at Calabar and Warri. These samples were analysed for pH, Ca, Mg, Na, K, NO_3-N, NH_4-N and P.

It was observed that the irrigation waters at the named rice irrigation schemes in Niger and Ilorin Provinces were all exceedingly rich in potassium which reached a peak figure in July-August. Potash applications are therefore unnecessary on these irrigation schemes.

These irrigation waters were relatively low in Ca and Mg but no visual symptoms of deficiency of these two elements were observed in the rice crop. Further experimentation is necessary, however, to determine the minimum requirement of the major varieties of *Oryza sativa* grown in Nigeria.

Ammonium nitrogen, nitrate nitrogen and phosphorus were only present as traces in these irrigation waters. Therefore, the rate of application of N and P to the rice crop on the irrigation schemes will be determined by the nutrient status of the soils.

It was also observed that the irrigation waters were fairly alkaline; this was counteracted in most cases by the fact that the soils were acid. Nevertheless, the sodium content of these irrigation waters in Niger and Ilorin Provinces presented no hazard compared to that posed by the sodium content of the tidal waters at Warri and Calabar.

In future, conductivity measurements will be added to the list of determinations to facilitate correlation with sodium adsorption ratio (S.A.R.) figures with a view to determining the extent of sodium hazard in the water at each location.

Salinity variations in mangrove swamps

In previous years difficulty has been experienced in establishing rice nurseries on the tidal mangrove swamp at Egbe Island, Warri during the months of July and August. In 1965, samples of water were taken monthly at high and low tides on the Federal Rice Research Substations fields at Warri. Determinations were made of Na, K, Ca, Mg, and of the pH, of the tidal water samples.

In general, salinity at both high and low tides at Warri was highest in the month of June. The S.A.R. figures were also relatively high. From the S.A.R. figures it would appear that the problem is not only that of the "very damp nature of the nurseries" as previously surmised, but also of a high S.A.R. The S.A.R. was lower at high tides than at low tides, but as it is impracticable to seed at high tides it would appear that September is the most favourable month, from salinity considerations, to seed rice at Warri.

Green Manuring and rice soil nutrient status

The experiment at Badeggi described in the rice agronomy section of this report (See Crop rotation experiments) was soil sampled throughout the dry season legume cropping period and the following wet season rice cropping period in 1964/65.

Every three weeks, starting from the planting time of the cowpeas, a composite soil sample from the top 10 inches was taken from each of the 16 treatments. Sampling was continued for eight weeks after the transplanting of the rice test crop. Analyses carried out were for moisture, organic C, available P, pH, No-$_3$N, NH_4-H and Total N.

From the data obtained it was observed that although there was no significant N×P interaction, there was a gradual increase in the level of ammonium nitrogen and nitrate nitrogen during the growth of the cowpeas compared with the control plot, and that this level was maintained during the burial of the cowpea haulm. This level of N was gradually depleted during the growth of the rice test crop reaching its minimum level at flowering time. The final N-level of the soil after double cropping was slightly lower than the initial level.

The yield response of the paddy to the legume crop was equivalent to an application of 67.5 lbs N per acre. However, statistically, this did not prove significant.

Irrigation practice and the application of nitrogen

It is usual to drain a paddy field before applying sulphate of ammonia. Owing to the general shortage of water on the Badeggi irrigation scheme the practice at the Federal Rice Research Station has been to close all irrigation entries to and outlets from a field before applying sulphate of ammonia. The fertilizer was then broadcast on the surface of the water and the inlets and outlets kept closed for three to four days. During this period, it was believed that most of the nitrogen was taken up by the rice plants.

Recently, an experiment was conducted to determine whether 3-4 days was sufficient to enable the maximum quantity of nitrogen to be taken up by the plants. Nitrogen, in the form of ammonium sulphate, was applied to seedlings of MAS 2401 fourteen days after transplanting at the rate of 3 cwts. per acre and $1\frac{1}{2}$ cwts. per acre. The experiment was carried out in the irrigated growth tanks at the Federal Rice Research Station, Badeggi.

Samples of seedlings, surface water, drainage water and site soil were taken on the date of transplanting and once every two days till the fertilizer application was made fourteen days after transplanting. Then the fertilizer was applied and sampling continued once every two days. The surface water and drainage water were analysed for NO_3-N, NH_4-N, the site soil for NO_3-N, NH_4-H and total N and the seedlings for total N.

It was observed that there was a gradual drop (except for fluctuations probably due to organic nitrogen fixation losses) in the NO_3-N+NH_4-N from the first day of transplanting to the 14th day when the fertilizer was applied.

Following the application of Ammonium sulphate, the N content of the surface water rose rapidly and then commenced to fall after five to six days. Soil N reached a peak eight days after application and subsequently decreased. Plant N reached its highest level twelve days after application.

It was concluded that the opening of the irrigation inlets and outlets should be delayed until at least six days after the application of the ammonium sulphate to ensure the greatest benefit from the applied nitrogen.

SOIL FERTILITY

Long term Acioa barteri fallow experiment, Benin

In this experiment there were four lengths of the *Acioa barteri* fallow; 2, 3, 4, 5, years. There was also a fallow of the natural regenerated bush of 4 years. Each of these treatments was followed by a 2-year cropping period.

The two-year cropping comprised interplanted yams, *Dioscorea cayanensis*, cassava, *Manihot utilissima* and maize, *Zea mays*.

The yams and maize were planted in April after the clearing and burning of the fallow. The maize was harvested in August and followed immediately by cassava. The yam remained until November/December when it was harvested. The cassava was harvested in the second year in August. During this second year the fallow was allowed to start its regeneration.

The treatments can therefore be summarised as follows:

A. 2 years cropping followed by 2 years fallow of *Acioa barteri*.
B. 2 years cropping followed by 3 years fallow of *Acioa barteri*.
C. 2 years cropping followed by 4 years fallow of *Acioa barteri*.
E. 2 years cropping followed by 5 years fallow of *Acioa barteri*.
D. 2 years cropping followed by 4 years fallow of natural bush.

During 1962 to 1964 the yields obtained from the individual crops tended to be low. Thus, approximately 3 to 4 tons of yams per acre and 4 to 8 tons of cassava tubers per acre may not have been too far below average yields, but the maize yield of 300 to 500 lbs of dry grain per acre was about 10 per cent of the potential yield. This was the inevitable result of the drastically reduced plant population which resulted from the intercropping. The maize spacing in these experiments was 8×4 feet corresponding to a plant population of 1400 per acre while the optimum sole crop maize spacing on these soils is now known to be 14,000 plants per acre.

In interpreting the results of the different fallow treatments over the three-year period, it has been assumed that any lack of full exploitation of the soil resources would be common to all the treatments. Yet, it has been illuminating to compare the effect of the five treatments on the mean overall total yields of all the crops in all the plots, added together for the three years 1962, 1963, 1964. These are tabulated in Table 14 below.

TABLE 14
MEAN TOTAL CROP YIELDS, 1962 TO 1964

Treatment	*Yield (in lbs)*
A	39,824
B	43,340
C	44,957
E	45,888
D	55,486

The pattern was the same as for the individual crop yields. Soil productivity evidently increased with increasing length of *Acioa barteri* fallow. However, no significant increases were obtained after the four-year period of *Acioa barteri* fallow, treatment C, whereas a 4-year fallow of the naturally regenerated bush, treatment D, resulted in the greatest effect on soil productivity.

Thus, no greater soil productivity has been shown to result from replacing the bush fallow with a planted tree fallow. For all the crops, the bush fallow was at least as good as the planted *Acioa* fallow in maintaining soil productivity.

The apparently greater beneficial effects of the bush fallow may be due to the fact that, in the absence of a dominant species with deep established roots, many more tree species and herbs proliferate when the land is left after harvest. This engenders a greater density of overall vegetation with the eventual return of more vegetative material and organic matter to the soil.

While the planted *Acioa* fallows costs more to establish initially, the geometrical pattern of the planted tree fallows effectively smothers all the other vegetation on the land so that the recurrent costs of clearing and cutting down the fallow and of land preparation for cropping may in fact prove cheaper.

REPORT ON THE RICE AND ROOTCROP BREEDING DIVISION

1. ROOTCROP BREEDING PROGRAMMES

Cassava Breeding

The cassava improvement programme was continued with emphasis on the yield evaluation of the extensive recent acquisitions of local varieties previously selected high yielding local varieties and hybrids at the various centres throughout the Regions.

Production of hybrids, temporarily suspended in 1964, was resumed to exploit the improved yield and mosaic resistance observed in some earlier produced hybrids and selected local varieties which have now been fully evaluated. It should be noted that the collections and trials to which reference is made were those planted in mid-1964 and harvested in mid-1965.

Variety collections

Eight hundred varieties were grown in the National Collection at Umudike. The morphological characters of each variety were recorded in October 1964 and the descriptions checked in April 1965, as the colours of the plant parts of cassava change with the season. The characters found most useful in the description of varieties were the colour of young and mature leaves, the colours of the petiole, stipule, young and mature stem, flowers, capsules and tuber. The growth and branching habit was also used in classification. The variety descriptions will be further checked in 1966 to provide data for a classification of cassava varieties.

The yields of varieties in localised collections were evaluated against replicated controls at nine centres in the four Regions.

In collections in the Riveraine Provinces of Northern Nigeria the local varieties Ani Kinami and Akechi gave the highest yields at Osara and Mokwa. At Yandev, none of the local varieties produced a significantly higher yield than the control variety 53101. Yields were very low in the collection at Samaru, where the highest yielder was the Yandev local variety Duasai.

At Umudike, Eastern Nigeria, nineteen local varieties were compared with the high yielding hybrid 60444. 60444 was the highest yielding variety and gave a significantly greater yield than fourteen of the local varieties. At Abak, twenty-one local varieties were compared with the hybrid 60506. Two local varieties and 60506 gave a significantly greater yield than the mean of this population. At Nekede, 60506 was compared with 60447, 53101 and thirty-three local varieties. 60506 gave the highest yield followed by 60447. The yield of 60506 was significantly higher than 53101 and thirty-one of the local varieties.

At Iyanomo in Midwestern Nigeria, thirty-four local varieties were compared with 53101. As in 1962, the local variety Oyibo gave a significantly greater yield than 53101. Fifty-eight local varieties were compared with 53101 at Akure, in Western Nigeria; four of these gave significantly greater yields than 53101.

The highest yield from a local variety was obtained at Moor Plantation, Ibadan, where in a collection of 108 lines, the variety Aboyade gave a yield equivalent to 22.7 tons per acre, significantly greater than one hundred and four of the varieties in trials. Aboyade showed only mild mosaic symptoms with no distortion of the lamina.

This series of collections has now come to an end. The highest yielding local varieties from these collections have now been moved to major selection centres at Calabar, Umudike, Iyanomo, Ibadan and Mokwa, where they are now being compared with 53101 in replicated field trials.

Regional variety trials

The highest yielding hybrids and local varieties were again compared in eleven trials. The standard variety in Eastern Nigeria is still GCH. 7 (37065). In trials repeated the third time at Abak, Nekede and Umudike in Eastern Nigeria, the hybrid 60444 was the highest yielding, followed by the hybrid 60506. Both hybrids gave a significantly higher yields than GCH. 7 at all three stations. At Abak and Nekede, 60444 also produced a significantly greater yield than 53101.

At Iyanomo in Midwestern Nigeria, only the hybrid 60488 produced a significantly greater yield than 60444. In contrast with the previous year, the hybrids 60448, 60438, 60444 and 631005 all gave significantly greater yields than 53101. At Agege and Akure in Western Nigeria, the hybrid 60444 was the highest yielding line while 60447 was the highest yielding line at Ibadan. There were, however, no significant differences between the yields of 60444, 60447 and 53101. 53101 is regarded as the Ibadan local variety; at Akure and Agege 60444 gave significantly greater yields than the local varieties.

In the Northern Nigeria trials, 60447 produced a significantly greater yield than 53101 and the local variety at Ilorin. At Mokwa, the hybrid 60480 was the highest yielding and gave a significantly greater yield than 53101, 60444 and the local variety. There was no significant difference between the yields of 60447 and 60444 at Osara. The hybrid 60447 gave a significantly greater yield than 53101 and the local variety. However, at Yandev there was no significant difference between the yields of the hybrid 60520 and 53101 although 60520 gave a significantly greater yield than any other variety in trials. At Samaru, there was no significant difference between the yield of the best variety CH.28 and the hybrid 60447.

It was not possible to carry out a joint analysis of this series of trials. The yield potential of the hybrids 60444, 60447, 60506 and 60480 was however clearly demonstrated, also the wide range of adaptation of 60444 and 60447. The trials have therefore been discontinued and the ten highest yielding hybrids, together with 53101 and the best local varieties are being compared in a trial replicated at the five main selection centres described above.

Progeny trials

Among the hybrids from the 1959 series crosses in trial at Umudike, three gave significantly greater yields than 53101. In non replicated collections, two hybrids at Umudike and four at Moor Plantation also outyielded 53101. All these yielding hybrids were derived from the cross 60452 × 58308. 60452 is itself a hybrid from the self pollination of the high yielding variety 53101. 58308 is a mosaic resistant interspecies hybrid between *Manihot utilissima* × *M. glaziovii*. Fifty hybrids were selected from the 1959 crosses and planted at Umudike, Iyanomo and Moor Plantation for evaluation in 1965/66.

At Umudike, the progeny of the 1960 and 1961 series of crosses were compared with 53101. Eleven hybrids outyielded 53101. These hybrids came from crosses between the varieties 58308 × 53101, 60452 × 53101 and 58308 × 42074. Two hybrids from the cross 58308 × 42074 remained free from mosaic symptoms throughout the season. 42074 is a variety of *M. utilissima* which shows some resistance to mosaic and several hybrids between this variety and the resistant 58308 have shown high level of mosaic resistance in the field. Ninety-four of these hybrids were planted in further trials in 1965.

From the foregoing paragraphs, it will be seen that 53101 and its progeny, and the interspecies hybrid 58308 appear to be very promising parent varieties and both high yielding and mosaic resistant progeny have been produced from them.

Hybridisation

A breeding programme to combine together the high yield of 53101 and the mosaic resistance of some of the recently produced interspecies hybrids was commenced. The

three highest yielding hybrids now available were all bred from 53101. Hybrids 60447 and 60506 came from the cross 42074 × 53101 and 60444 came from the cross 32031 × 53101. Of the cassava parent material available when the crosses were originally made, 42074 and 32031 then showed the highest levels of resistance to cassava mosaic. These three hybrids, and 53101 have now all been crossed with the highly mosaic resistant interspecies hybrids 58308, 58198 and 58212 now available. Some 15,000 hand pollinations were made in this programme.

Preference tests

The quality of gari (the principal cassava product) made from cassava varieties in the 1965 trials was compared at three centres. The samples were tested by independent judges and the results compared by Snedecor's method. At Nekede, the hybrid 60506 was preferred followed by 53101. 60447 and 60444 also made good gari. At Umudike and Ibadan, the old variety Congo (44086) gave the highest out-turn of gari and, at Ibadan, was preferred in quality to that made from 60447 and 53101.

II. RICE BREEDING PROGRAMMES

Rice cultivation in Nigeria occurs in four major ecological zones; the naturally inundated lowlands, the fresh water mangrove swamps, the non-inundated irrigable lowlands and the rainfed uplands. Currently, these zones are characterized by the cultivation of three distinct types of rice; the first zone by floating rice, the second and third zones by swamp rice and the fourth zone by upland rice. The rice breeding and agronomy programmes of the Division are sub-divided accordingly.

Floating Rice Breeding

The object of the floating rice breeding programme is to produce white grained, floating varieties of *Oryza sativa* to replace the traditionally grown, red grained varieties of *Oryza glaberrima* in the naturally inundated lowlands.

Variety trials, Badeggi

The standard floating variety Mali Ong was compared for a third year at Badeggi with five *O. sativa* varieties of shorter duration and with two high yielding popular varieties of *O. glaberrima*, Badande and Dan Boto. In 1965, Mali Ong was again the highest yielding variety in trial. It produced a significantly greater yield than all the other varieties except Badande. In a joint analysis of the data from three annual replicates of this trial, Mali Ong gave a significantly greater yield than all the other *O. sativa* varieties. Its average yield was not significantly greater than Dan Boto. However, Mali Ong is to be preferred to *O. glaberrima* varieties, as its long white grain commands a higher market price than the short, red grain of Dan Boto.

Breeding for shorter duration

Progeny trials, Badeggi. Mali Ong is of slightly too long a duration for cultivation in some parts of the naturally inundated lowlands. In the programme to produce short duration floating lines, 109 F_5 progenies from three crosses between the high yielding varieties Mali Ong, Champa and Indo Chine 53 and the short duration Indo-Chine Blanc, were compared with Mali Ong at Badeggi. All the progenies were earlier than Mali Ong. Two progenies, 41/9 and 41/11, gave significantly greater yields than Mali Ong. Thirty-four early progenies, whose yield did not differ significantly from Mali Ong, and which showed a good floating habit were retained.

From a further series of five crosses, in which the swamp varieties BG 79 and Bhendot T/100 were crossed with the floating lines, Mali Ong and Tisei, thirty-three F_4 progenies

were compared. Marked segregation for plant habit and grain type occurred. The floating habit of these progenies was not good and only eight were retained for further trial.

Progeny trials, Birnin Kebbi. Twenty F_5 progenies of these crosses were tested under natural deep flooding conditions at Birnin Kebbi. The yield of Mali Ong was low here in 1965 and it was outyielded by Indo Chine Blanc, which produced 1500 lbs per acre. Five hybrids of the same life period as Indo Chine Blanc, gave yields over 2000 lbs per acre. Progeny 41/9 again yielded well at Birnin Kebbi giving 2063 lbs per acre.

Interspecies hybrids

In a breeding programme to combine the vigour and flood resistance of *Oryza glaberrima* with the white grain and non-shattering habit of *O. sativa* twenty-one interspecies hybrid progenies were compared with Mali Ong and Dan Boto at Birnin Kebbi. These progenies were in the F_7 generation and still showed a high degree of sexual sterility. None of them produced a higher yield than the controls and further selection within these populations is still required.

SWAMP RICE BREEDING

The main object of the shallow swamp rice breeding programme is to produce high yielding, blast resistant, non-lodging varieties, having the same or shorter duration than the standard variety Mas 2401 and BG. 79.

Variety collections

The current collections of introduced varieties were compared with control varieties of similar duration at the Badeggi, Bende and Warri substations. Seventeen medium duration varieties gave significantly greater yields than the BG 79 control at Badeggi while thirty-one gave significantly greater yields than BG 79 at Bende; of these varieties HMA-9 significantly outyielded BG 79 at both centres. Only seven varieties gave significantly greater yield than BG 79 at Warri. Seven shorter duration varieties gave a significantly greater yield than their control MTU-9 at Badeggi; of these the variety Puang Ngeon 6/16 gave a significantly greater yield than the control variety at both Badeggi and Bende. Both Puang Ngeon and HMA-9 were resistant to rice blast.

Thirty-eight long duration lines were also compared with KAV 12 at Badeggi, of which twelve gave significantly greater yield than the control.

Variety trials, Badeggi

Fourteen varieties, selected from the 1962-64 replicated variety collections, were compared with Mas 2401 and BG 79 in a new yield trial at Badeggi. ASD-II gave the highest yield, equivalent to 3000 lbs per acre. This variety, SR-26B and B-43-11 all gave significantly greater yields than BG 79 or Mas 2401.

A further fourteen varieties had been selected for high blast resistance in I.R.R.I. type Blast nurseries grown in 1964. These were also compared with Mas 2401 and BG 79 in another trial at Badeggi. The resistant varieties Fossa and HMA-9 gave significantly greater yields than Mas 2401 and BG 79.

Six long duration varieties were compared with Bolo 108 and Siam 29 for a fourth time at Badeggi. There were significant differences between variety yields, but the highest yielding line, Gambiaka Sebela, was not significantly higher yielding than the controls. In a joint analysis of four years data from this trial, Gambiaka Sebela was the highest yielding, but its yield was not significantly greater than the yield of Siam 29. Siam 29 therefore remains the recommended 6-month variety.

Regional variety trials

The yields of six varieties were compared in a trial on the Yau Irrigation Scheme, Bornu Province, to select the best variety for cultivation on the saline-alkaline soils in this

area. This trial was also replicated on the South Chad Irrigation Scheme at Tunokaka. In both trials, De Gaulle was the highest yielding variety, giving yields equivalent to 4410 lbs. per acre at Yau and 4813 at Tunokaka. In both trials it produced a significantly greater yield than the control variety Mas 2401.

Seven varieties were again compared at Ago Amodu, Oyo Province to select the best variety for cultivation in the rainfed basins of the Shaki area. In 1964, D.114 was the highest yielding variety. In 1965, there were no significant differences between the yields of BG 79, D.114 and Makalioka 823.

Five varieties were compared with Mas 2401 at the Bende substation. The varieties E.1 and BG 79 both gave a significantly greater yields than Mas 2401.

Breeding for lodging resistance

The programme to produce lodging resistant lines was continued. Yield comparison of the F_7 progenies derived from the three original 1958 crosses was again carried out in replicated trials at the Badeggi, Bende and Warri substations. At all locations there were significant differences between the progeny yields, but none produced a significantly greater yield than the standard variety Mas 2401. A total of 140 progenies were compared in these trials. Thirty-seven have been retained as lodging resistant and will be tested at all three stations in 1966.

Breeding for shorter duration

The programme to produce high yielding, short duration varieties was continued at the Badeggi and Bende substations. Three hundred of these progenies were yield-tested at Badeggi and forty at Bende. The promising progenies which were selected in 1964, from the 1958 crosses between BG 79 × MTU-9, BG 79 × Precose and CEB 24/37 × Precose proved to be highly susceptible to rice blast in 1965, both in the nursery stage and at flowering. As a result their potential value is much reduced and only fourteen of these progenies have therefore been retained for further trial. By contrast, the crosses between BG 79 and Tai Chu 65 were more promising in 1965. They showed a high level of resistance to blast and were earlier than BG 79. Thirty-five of these progenies have been retained for further trial and individual plant selection in the F_6 generation.

Breeding for blast resistance

Selection. The blast nursery technique has been developed to test varieties for resistance to rice blast caused by *Pyricularia oryzae*. Seedlings of the varieties under test are grown in upland nurseries between rows of susceptible seedlings which are heavily infected with the disease. Under these epiphytotic conditions very precise selection for resistance can be carried out.

A total of 465 varieties were screened in such blast nurseries in 1965 of which eleven were classified as highly resistant and 83 as resistant.

Breeding. Twenty-two F_2 progenies, the product of the 1964 diallele cross programme in which seven highly resistant swamp varieties were crossed with the standard variety Tjina, were screened in the blast nurseries and twenty-one proved to be highly resistant to blast. One progeny showed segregation for resistance, some individual seedlings being classified as moderately resistant. None of the F_2 progenies showed symptoms of neck blast or leaf blast in the field. Five of these progenies gave yields ranging from 3100 to 3776 lbs per acre.

In view of the increasing importance of blast, all the hybrid progenies retained from earlier hybridisation programmes for lodging resistance and short duration were also

screened. All the susceptible lines were eliminated and only the highly resistant progenies have been carried into 1966.

In addition, a further series of crosses, to produce short duration, blast resistant swamp rice lines were made at Badeggi in 1965. Six promising short duration lines were selected as parents and crossed with Mas 2401 and Tjina. The F_1 generation was grown at Badeggi in 1965 and the F_2 generation will also be screened in blast nurseries.

UPLAND RICE BREEDING

Variety collections

The upland rice breeding programme is designed to produce long grained, blast resistant varieties which are able to respond to fertilizer applications. Twenty-one new introductions were compared with Agbede 16/56, the standard upland variety, in replicated collections at Moor Plantation and Irrua. However, none of these varieties proved significantly higher yielding than Agbede 16/56. Five white grained varieties of *Oryza glaberrima* showed very high resistance to rice blast, but they were too long duration for upland cultivation in the West and Midwestern Nigeria.

Regional variety trials

Five varieties, selected from the 1963 and 1964 variety collections, were compared with Agbede 16/56 at five centres in 1965. The variety OS.6 was outstanding in these trials. It produced a significantly greater yield than Agbede 16/56 at Ibadan, Wasimi, Ado-Ekiti, Irrua and Jemma's. At Ado-Ekiti, the short duration upland variety E.425 also gave a significantly greater yield than Agbede 16/56. The average yield of OS.6 in these trials was 2844 lbs per acre, compared with an average of 1839 lbs per acre from Agbede 16/56.

Breeding for blast resistance

In 1964, three high yielding upland varieties were crossed with the blast resistant swamp variety Tjina in a breeding programme to produce blast resistant upland varieties. The F_2 generation from these crosses was screened for blast resistance in the seedling stage and the resistant individuals selected and grown. Early in 1965, the dormancy of the F_2 seed and subsequent germination was broken by heat treatment and selection for long grain type and upland plant habit continued in the F_3 and F_4 generations.

III. RICE AGRONOMY PROGRAMMES

SWAMP RICE AGRONOMY

Plant population studies

Trials conducted at Badeggi from 1959 to 1962 led to the recommendation that shallow swamp rice in the Niger riveraine areas should be transplanted in rows 12 inches apart, the plants 3 inches apart in the row, that is 36 square inches per plant.

Further trials were commenced in 1965 at Badeggi and Warri to examine the interaction between nitrogen response and spacing. An extended range of unit areas per plant from 144 to 16 square inches was used and each unit area was studied as a 2:2 square or a 1:4 rectangle. Ammonium sulphate was applied at nil, 1½ and 3 cwts per acre.

At Badeggi, a unit area of 36 square inches again gave a significantly greater yield than unit areas of 64 or 100 square inches per plant. However, no significant response was obtained from the applied nitrogen nor was the interaction between nitrogen and spacing significant. The experiment will be repeated.

At Warri, on the mangrove soils, plants spaced at 2 × 8 inches gave a significantly greater yield than plants spaced at 5 × 20 inches, 10 × 10 inches, 8 × 8 inches, 6 × 6

inches and 3 × 12 inches. There were no significant differences between the yields of plants spaced at 2 × 8 inches, 4 × 4 inches and 4 × 16 inches. Applications of 1½ and 3 cwts. per acre of sulphate of ammonia gave significant increases in yield when compared with the no nitrogen control. There was no significant difference between the yields obtained from applications of 1½ and 3 cwts per acre. The interaction between spacing and levels of nitrogen was not significant.

Crop rotation experiments

Previous experiments have shown that the two most promising rotations were rice/cowpeas and rice/groundnuts. A cowpea preference test was conducted in the six major rice growing areas around Badeggi in late 1964. It was shown that a clear preference existed for white skinned black eyed cowpeas. Seven selected cowpea lines of this type were evaluated together with one groundnut variety and a naturally regenerated grass fallow in a dry season experiment in 1964/65. The cowpea variety Kwara ex Kwoi gave a significantly greater yield than any other cowpea line.

After harvest in 1965, the haulm of the legumes and the fallow grass was turned into the ground. The legume plots were split for applications of superphosphate at nil and two cwts. per acre. All plots of the experiment were then test-cropped with rice to investigate the residual manurial effects of the dry season crop. However, no significant responses to the green manuring or to the application of superphosphate were observed in 1965 and the experiment failed to confirm the positive results of 1964.

Fertilizer trials

The interactions between three rates, times and methods of application of ammonium sulphate were studied in a trial at Badeggi. Applications of 2 and 4 cwts per acre of ammonium sulphate produced significant increases in yield compared with the no nitrogen control. However, there was no significant difference between the yields from 2 and 4 cwts per acre, nor did the three different times and methods of application treatments produce a significant response.

In a trial to study the responses of four recommended varieties to give levels of nitrogen application at Badeggi, Mas 2401 gave a significantly greater yield than Makalioka 823, D.114 and BG.79. Applications of 3 cwts per acre of ammonium sulphate gave significant nincreases in yield. Applications of 4 cwts per acre caused decreases in yield with Makalioka 823, D.114 and BG.79 and only with Mas 2401 did the yield increase remain linear. Tiller number also decreased with applications of more than 3 cwts per acre.

Regional fertilizer trials. In 1965, no significant response to applications of nitrogen and phosphorous were obtained from direct seeded BG.79 in the Jere Bowl in Bornu Province. However, in a joint analysis of data from the 1963, 1964 and 1965 replicates of this trial, applications of 4 cwts per acre of sulphate of ammonia applied as 2 cwts at seeding and 2 cwts four weeks later gave a significant yield increase over the no nitrogen treatment.

The fertilizer response of BG.79 on the saline-alkaline soils at Yau was further studied in a 3 × 3 factorial trial. Highly significant yield increases were obtained from applications of 4 cwts of sulphate of ammonia per acre. No significant response was obtained from applications of 1 and 2 cwts per acre of superphosphate or 1½ and 3 cwts per acre of muriate of potash. The interaction between N, P and K applications was not significant.

Herbicide trials

In a trial to study the use of Stam F-34 (3, 4, dichloropropionanilide) in post-transplanting weed control in rice, four levels of herbicide treatment were compared at Badeggi. No significant yield differences were observed between the different levels of application of Stam F-34, but the most efficient weed control was obtained with two applications of 4½

lbs active ingredient per acre, applied fourteen and forty-two days after transplanting. Complete control of the dominant weeds, *Cyperus* and *Scirpus* species, *Barcopa crenata*, *Sphenochlea zylandica* and *Burnetial anandia* was obtained.

At Edozhigi, near Badeggi, four levels of Gramevin (2, 2 dichloropropionate), applied four weeks before transplanting, were compared in a 4×3 factorial trial with three levels of application of Stam F-34 applied as a post-transplanting treatment. No significant yield response to applications of Gramevin were obtained, but effective control of the perennial weeds species which dominate the fadama after the early rains was achieved. *Oryza barthii*, *Echinocloa colonum* and *Leptochlea caerulescens* were most effectively controlled by Gramevin applied at 10 lbs of active ingredient per acre.

Compared with the yield of the hand weeded control, a significant yield increase, and effective control of the broad leaved weeds was obtained with an application of Stam F-34 at 6 lb active ingredient per acre. This experiment was repeated using direct seeded rice; again a significant yield increase, and the most effective weed control, were obtained from the Stam F-34 treatment applied at 6 lbs per acre.

UPLAND RICE AGRONOMY

Spacing and fertilizer trials

To determine the response of the current standard variety Agbede 16/56 to various spacings and fertilizer applications, a 3^4NP spacing trial was planted at Wasimi in Western Nigeria. Ammonium sulphate and superphosphate were applied at 0, 100 and 200 lbs per acre and muriate of potash at 0, 40 and 60 lbs per acre. The rice was direct seeded at 12×9 inches, 12×12 inches and 12×15 inches. The only significant fertilizer response was obtained from 100 lbs sulphate of ammonia applied to rice relatively widely spaced at 12×15 inches. This confirmed previous indications that the lax habit of this variety limited the leaf area receiving solar radiation at close spacing and thus limited its response to nutrients at close spacing. The best non fertilized yields of Agbede have generally been obtained at the relatively wide spacing of 12×12 inches.

The interaction of nitrogen applications and spacing was further studied at Ibadan in a $2^2\times3$ factorial trial using Agbede 16/56 and the short grained, high yielding variety Jete. There was no significant difference between the average yields of the two varieties. There was no significant difference in the yield of plants spaced at 12×12 inches or 12×6 inches, but both spacings gave a highly significantly greater yield than plants spaced at 12×18 inches. Yield response to 200 lbs sulphate of ammonia per acre were highly significantly greater than the responses to 100 lbs sulphate of ammonia per acre.

There was significant interaction between nitrogen $\times$ variety; both Agbede and Jete showed increases in yield with applications of 200 lbs of sulphate of ammonia per acre, but only with Jete was the response large enough to be significant. The spacing $\times$ nitrogen interaction was also significant. Significant yield increases were obtained from 200 lbs of sulphate of ammonia per acre at the spacings of 12×12 inches and 12×6 inches.

Thus, as in the Wasimi trial, Agbede 16/56 responded poorly to the application of fertilizer. However, Agbede 16/56 will be replaced by the higher yielding, long grained OS.6 in 1966.

REPORT ON THE AGRONOMY DIVISION
MAIZE AGRONOMY

N.P.K. fertilizer trials

Fertilizer experiments to study the effect of three levels of nitrogen (as sulphate of ammonia), three of P_2O_5 (as superphosphate) and three of K_2O (as sulphate of potash) on the yield of maize have now been carried out for three consecutive years (1963-1965) at Moor Plantation, Ibadan.

The result of the 1965 trials has confirmed results obtained in the previous years. The application of 40 lbs per acre of nitrogen resulted in significant increase of from 2679 to 3388 lbs per acre of dry grain. There was a further non-significant increase of 353 dry grain per acre with an additional application of 40 lbs per acre of nitrogen.

There was neither significant response to applications of P_2O_5 nor K_2O in 1965. There were also no significant interactions between any of the fertilizers. These results, in general, confirmed the findings of previous years.

On the basis of these results, it is evident that apart from other soil conditioners, good yields of maize can be achieved at Moor Plantation with the application of nitrogen alone.

Time and method of nitrogen application

Studies of the yield response of maize to nitrogenous fertilizers have been carried out at a number of agricultural research stations in the Federation since the early 1950s but the yield responses indicated by these experiments have been very varied. Sometimes, increases in yield of up to 60 per cent have been obtained with the application of as little as 40 lbs per acre of nitrogen and in other years less than 30 per cent increase in yield has been obtained with the same amounts of nitrogen at the same station. It is believed that the differences in response of maize to nitrogen applications are probably attributable to varying losses of the fertilizer by leaching.

In view of these observed differences in response to nitrogen applications, an experiment was commenced on Moor Plantation, Ibadan, in the early season of 1965, to determine the optimum time and method of application of sulphate of ammonia to the maize crop. Method here meant single versus split applications. Early experiments have already shown that localised applications of sulphate of ammonia in close proximity to the plants give better results than broadcasting over the entire surface, either before or after ploughing.

A split plot design was used. The four times of application of the first dose of nitrogen constituted the main treatments. The first dose of nitrogen (as ammonium sulphate) was either applied on the day of sowing (T1), or at two (T2), four (T3), and six (T4) weeks after sowing respectively.

The main treatment plots were further subdivided into four sub-treatment plots. The first sub-treatment (DO) was O16N, the second (D1) was 60 lbs N. to the acre applied in a single dose and the third was the same amount applied in two doses of 30 lbs N/acre each; the fourth (D3) was the same 60 lbs N to the acre in three doses of 20 lbs each. Forty pounds per acre of P_2O_5 (as superphosphate) was applied on the day of planting to all the plots. The entire treatments were replicated three times. The maize variety used was Eafro 231.

The results have shown that, on the whole, irrespective of the time nitrogen was first applied, there was no significant difference in yield between plots which received no nitrogen (3635 lbs of dry grain per acre) and those which received 60 lbs of N in a single dose (3741 lbs/acre). An average yield of 4000 lbs of dry grain per acre was obtained from plots which

received 60 lbs of N applied in two doses of 30 lbs each. A further average increase in yield amounting to 210 lbs per acre was obtained from plots which received 60 lbs. of N in three doses of 20 lbs each. In other words, there were increases of 10 and 16 per cent over the control (no nitrogen) when 60 lbs of nitrogen was applied in two and three doses respectively.

The yields obtained from plots which received two or three doses of nitrogen were significantly superior to those obtained from plots which received nitrogen in one dose.

There were no significant differences in yield due to different dates of applications but there were, however, as can be seen from the Table XV below, significant differences in yield due to the interactions of dates × doses.

TABLE 15

YIELD RESPONSES (LBS/ACRE) OF EAFRO 231 60 LBS N/ACRE WHEN APPLIED AT VARIOUS DOSES AND TIMES

Treatment	*DO*	*D*1	*D*2	*D*3	*Mean*
T1	3506	3724	3642	3874	3686
T2	4260	4128	4262	4460	4277
T3	3052	3898	4262	3876	3772
T4	3742	3218	3932	4598	3868
Mean	3635	3742	4024	4202	
	L.S.D. @ 5%=609				

Good yields were generally obtained when nitrogen was applied two weeks after planting and still better when applied in three doses at two weekly intervals.

The fact that there was no significant difference in yield between plots that received no nitrogen and those that received 60 lbs N/acre in a single dose could be attributed to the porosity of the sandy Ibadan soil and to the heavy tropical rainfall which facilitated the rapit leaching of sulphate of ammonia.

Plant population studies

An experiment was conducted at Ibadan during the early season of 1965 to determine the yields of maize variety, Eafro 231, at various stand populations. This experiment was initiated primarily because of the higher operational costs (planting, seeding, fertilizing, etc.) involved in planting one plant to a hill instead of two or more for any given field population (number of plants per acre).

Four stand populations consisting of 1, 2, 3 and 4 plants with a common field population of 17,400 plants to the acre were tested in a simple randomized block design of five

replications. Each plot, consisting of 144 plants, was made up of four 3-ft. ridges of 30 ft. in length. The stands of 1, 2, 3 and 4 plants to a hill were planted 10, 20, 30 and 40 inches apart respectively. A mixture of 60 lbs N (as sulphate of ammonia) and 40 lbs P_2O_5 (as superphosphate) per acre was applied by hill placement and in proportion to the number of plants to the hill. The yield result is summarised in Table XVI.

TABLE 16
YIELD RESPONSE OF EAFRO 231 TO DIFFERENT STAND POPULATION AT A CONSTANT FIELD POPULATION

Plant population (*N/acre*)	*Stand population* (*N/stand*)	*Yield* (*lb/acre*)
17,400	1	4816
17,400	2	5034
17,400	3	5188
17,400	4	4898
C.V.	–	11%
L.S.D.	–	N.S.

The analysis of variance revealed no significant yield differences from plots planted 1, 2, 3 and 4 to the hill. On the basis of these results and on similar ones obtained in 1964 at Moor Plantation, it would appear more economical to plant two or more plants to a hill at a wider spacing than to plant one plant to a hill at close spacing.

National zonal yield trials

During the year 1965, 24 national maize yield trials were carried out in the principal maize growing centres in the country. The objective of these trials, in which improved agricultural practices were employed, was to facilitate the selection of promising varieties best suited to specific ecological zones. The complete data from all these trials will be reported in a separate publication but the data from the trials conducted at Ibadan and Ilora in the past three years, including 1965, by the Agronomy Division of the Federal Department of Agricultural Research are summarised in Table XVII. Note that for 1963, only the yields of those varieties common to the previous and the current series of zonal yield trials are given.

The results to date at these two stations indicate that the variety H 503 is probably superior to NS-1 but may not be significantly superior to Eafro 231. Both H 503 and Eafro 231 have white dent grain while NS-1 has yellow flint grain.

Table XVII also clearly indicates the steady and progressive increases in yield of nearly all maize varieties entered at Ibadan in the past three years in response to improved agronomic practices. Such a trend was also expected at Ilora in 1965 but the yields were depressed by a severe dry spell which occurred in the early months (March to mid-May). Nevertheless, the variety Lagos White, which is somewhat tolerant to drought, has shown a consistent and steady increase in yield even at Ilora.

Table 17

Maize Yield Results (Lbs/Acre) at Ibadan and Ilora in the 1963, 1964 and 1965 Trials

Variety	Ibadan			Ilora		
	1963	1964	1965	1963	1964	1965
NS-1	2118	2817	3915	3110	3660	3549
Eafro 235	2105	2733	2254	2868	3683	2097
Eafro 231 ..	1827	3187	4002	2977	4412	3779
H 507	—	3064	3997	—	4166	3997
H 503	—	2869	4658	—	4394	4251
V1 Ex W/R ..	—	2989	3467	—	4218	3446
Diacol V-153 ..	—	2814	3832	—	3701	3494
NS-5	—	2565	3889	—	3485	3207
NS-4	—	2471	3341	—	2892	3026
Lagos White ..	—	1961	3459	2819	2852	3042
Average yield ..	1985	2747	3681	2944	3746	3389
L.S.D. 5% ..	—	530	922	—	430	526
C.V.	15%	17%	12%	15%	10%	12%

GRAIN LEGUME AGRONOMY

Cowpea spacing v. habit experiment

Three cowpea varieties, namely, acquisition Nos. 1, 157 and 201 representing respectively erect, semi-erect and trailing growth habit types were included in a spacing trial conducted in both the early and late seasons of 1965. The spacings used were 6, 9, 12, 15, 18 inches apart on 3-ft. ridges giving approximate plant populations of 29,000; 19,400; 14,500; 11,600; and 9700 plants per acre respectively.

Analysis of the similar data from the two experiments revealed no significant yield differences between the varieties representing the three growth habits. The highest yield of dry grain was obtained at a plant population of 14,500 plants per acre but there were no significant differences between the yields obtained at the 19,400; 14,500; and 11,600 plant populations. Yields obtained at these populations were significantly superior to the yield obtained at the 9700 plant population. The variety × spacing interaction did not attain significance in these experiments.

CASSAVA AGRONOMY

The effects of storing periods, Lengths of cutting and depths of planting on yield of cassava

Factorial experiments were conducted at Ibadan and Umudike in the 1965/66 season to study the effects of (*a*) periods of storing cassava cuttings before planting; (*b*) lengths of cutting; and (*c*) planting depths, on yield of cassava. Cassava hybrid No. 53101 was used in both locations.

It was found in both locations that the stored cuttings yielded significantly higher than the unstored cuttings although there were no significant differences in yield between the cuttings stored for 10 or 20 days before planting. Increased yields obtained from stored cuttings were probably a consequence of the earlier start made in their establishment, for, while the stored cuttings progressively developed root systems and leaves from the first month of the experiment, the establishment of the unstored cuttings was much slower.

The results also showed that yields increased progressively with the increasing length of cuttings from 6 to 18 inches. The most probable explanation is that longer cuttings with more buds and consequently developing greater leaf area would, within a season's growth, produce more tubers than those cuttings with a fewer number of leaves.

Spacing studies

In an experiment carried out at Umudike in 1964, it was discovered that when three cassava varieties with different growing habits (N.53101-low branched, No. 43083-medium branched and No. 44086-unbranched) were planted at a constant unit area per plant of 12 sq. ft., they all gave higher yields in 4-foot ridges than in either 3 or 6-foot ridges. Further investigations were continued at Umudike and Iyanomo in 1965 to determine the yields of these same varieties at 2, 3, 4, and 5 ft. spacing on 4-foot ridges.

The results of the experiments are summarised in Table XVIII.

TABLE 18
YIELDS (TONS/ACRE) OF 3 CASSAVA HYBRIDS AT 2, 3, 4 AND 6-FT. SPACINGS ON 4-FT. RIDGES

Spacing	UMUDIKE			IYANOMO		
	No. 53101 (*Lo*	*No.* 43083 (*Medium*)	*No.* 44086 (*Unbranched*)	*No.* 53101 (*Low*)	*No.* 43083 (*Medium*)	*No.* 44086 (*Unbranched*)
2 ft.	10.5	11.7	9.0	8.8	10.8	10.8
3 ft.	9.7	11.4	6.8	8.7	9.0	9.0
4 ft.	7	10.1	6.5	9.5	9.3	7.8
6 ft.	6.3	9.0	5.3	9.0	8.4	7.1
	L.S.D. at 5% NS			L.S.D. at 5%=1.6 tons/acre		

Although the analysis of the Umudike trial indicated no significant differences in yield due to different spacings, there was a general tendency for all varieties to yield progressively higher with decreasing spacing. The same yield trend was also the same at Iyanomo where the medium branched and the unbranched varieties gave significantly higher yields at 2 ft. than at 6-ft. spacing. However, the same yield trend was not observed at Iyanomo with the low branched variety 53101.

YAM AGRONOMY

Spacing studies

Studies were continued at Umudike to determine the optimum plant population of *D. rotundata*. Results in 1965 were essentially in agreement with those obtained in 1964 It was found that yields were not affected by the different widths of ridges used (3, 4 and 6 ft.). Both trials also indicated progressive increase in yield as plant spacings were decreased. One foot spacing gave higher yield than either 2 or 3 ft. spacings regardless of ridge width. Again, as in 1964, the size of tubers was generally larger at the wider spacings.

Mulching studies

Previous trials have clearly shown that significant yield increases of about 30 per cent or more are frequently obtained when yams are mulched. Because of the high cost involved in mulching the entire field with leaves or grasses it was considered that capping, which consists of covering only the tops of the ridges or hills would probably result in similar increases in yield at less cost.

During the year, a factorial experiment was conducted at Umudike to compare the yield and percentage germination of *D. rotundata* in bare (control), mulched, and capped plots at three ridge widths, namely 3, 4 and 6 ft. A constant unit area per stand of 12 sq. feet was used in all treatments.

Results showed that there was no significant differences in yield or in percentage germination between mulched and capped plots. It was also found that both mulching or capping increased the yield by about 34 per cent. The average percentage germination of both capped and mulched yams was also about 4.5 per cent higher than the average percentage obtaining on the control plots. Furthermore, it was observed that most of the setts in capped and mulched plots germinated earlier than the setts in the control plots. There were no significant yield differences between the different ridge widths used. On the basis of these findings, and similar results from earlier experiments, it can be concluded that in order to ensure the highest economic returns capping is to be preferred to mulching.

SWEET POTATO AGRONOMY

Time of planting and harvesting studies

Continuing previous work, field experiments were laid out at Umudike and Ibadan in 1965 to study the effects of time of planting and harvesting on the yield and quality of sweet potatoes. A randomized block design of experiment was used with treatments consisting three dates of planting (1st weeks in May, June and July) and four harvesting periods (120, 140, 160 and 180 days after planting).

Highly significant differences in yield were exhibited between the various dates of planting (See Table XIX).

TABLE 19
MAIN YIELD (TONS/ACRES) OF SWEET POTATOES

Planting Date	*Harvesting Days from Planting*								*Mean Yield*	
	120		140		160		180			
	lb.	*Um.*	*lb.*	*Um.*	*lb.*	*Um.*	*lb.*	*Um.*	*lb.*	*Um.*
May	2.1	2.2	2.1	2.0	4.1	3.1	3.1	3.8	3.0	2.8
June	4.2	2.1	5.0	3.9	3.0	2.7	4.3	4.0	4.3	3.4
July	2.1	1.0	2.2	1.6	1.7	1.5	1.7	2.1	1.9	1.6
Mean Yield	8.4	5.3	9.3	7.5	9.6	8.3	9.8	10.0	—	—

In both locations, June plantings generally yielded higher than May plantings though the differences were not significant. But sweet potatoes planted in May gave almost twice as much yield as those planted in July.

It was observed that incidence of tuber cracking and weevil attacks increased the longer the potato tubers remained in the ground. It was therefore concluded that, for the rain forest areas, the optimum planting period is between late May and early June and that to lessen tuber cracking and weevil damage, the tubers should not be left in the ground for more than about 150 days after planting.

EVAPOTRANSPIRATION STUDIES

Observations on the evapotranspiration of various crops were continued in 1965. The experiment consists of a number of plots each with three lysimeter tanks as designed by Professor Garnier. One standard plot was planted to bahama grass (*Cynodon dactylon*); six other plots were cropped with upland rice in the early season and groundnuts in the late season.

In these six plots three have been continuously under elephant grass mulch since September 1963 and three others have been left unmulched. Both mulched and unmulched plots have received the same amount of fertilizer throughout their history.

In order to keep the tanks at the field capacity necessary to obtain data for the potential evapotranspiration, two of the tanks in each mulch and unmulched plot received sufficient water daily to guarantee a regular outflow of water. No water was added to the third tank in each of these plots which therefore only received rainfall. Water collected from these tanks represented the quantity that seeped through the top soil and was unutilized by the crops.

Early season

The upland rice variety, Agbede 16/56 was sown on the 22nd March—at the recommended spacing—and harvested on the 19th of August, 1965. The daily average (118 days) evapotranspiration figures were as follows:

Mulched	(average of 6 tanks)	6.54 mm
Unmulched	(,, ,, ,,)	7.88 mm
Standard	(,, ,, ,,)	3.93 mm
Calculated evapotranspiration (Garnier's formula)		3.54 mm

Although the crop on the unmulched plots was markedly thinner and shorter, the evapotranspiration was 20 per cent higher than in the mulched plots. The data also indicated that the unmulched plots of upland rice lost considerably more water through evapotranspiration than the standard plots.

The mulched and unmulched plots which were given additional water (apart from rain water) received in their tanks a total of 965.0 and 989.8 mm of water respectively. Of these total the tanks in the mulched plots drained away 478.1 mm and those in the unmulched plots 381.3 mm of water. Thus more water was lost by drainage from the mulched than from the unmulched plots. These data clearly indicated that the substantial quantity of water lost through evapotranspiration in the unmulched plots could have gone a long way to keep the plots at field capacity.

Late season

Groundnuts were planted in the late season in the same plots that were previously planted to rice. A spacing of 24 inches × 6 inches was used. The crop was planted on the 17th of August and harvested on the 3rd of January, 1966.

The daily average (138 days) evapotranspiration figures were as follows:

Mulched	(average of 6 tanks)	2.01	mm
Unmulched	(,, ,, ,,)	3.51	mm
Standard	(,, ,, ,,)	3.30	mm
Calculated evapotranspiration (Garnier's formula)		3.71	mm

There was a close similarity in the rate of evapotranspiration of the mulched groundnut and the standard plots. It was also observed that daily average evapotranspiration figure were noticeably higher in the unmulched than in the mulched plots.

The tanks which (apart from receiving natural rainfall) had some water added in critical periods, received a total of 485.7 mm of water in the mulched and 557.7 mm in the unmulched plots. The outflow was 285.7 mm and 265.2 mm for the tanks in the mulched and unmulched plots respectively. As was the case with the upland rice, more water was lost through drainage in the mulched than in the unmulched plots.

Results

It has so far been observed that over the years, the beneficial effects of mulching are more pronounced in the late than in the early seasons. While mulching in the late season has increased yields of maize, groundnuts and rice by 20 per cent or more, no remarkable increases in yield have been observed in the early seasons. These results were to be expected because moisture is usually limited in the late seasons and any successful means of conserving soil moisture during the late seasons inevitably results in increased yields.

REPORT ON THE LIBRARY AND PUBLICATIONS SERVICE

Library

The scope of the Service was widened during the year by the purchase of a Rotaprint machine which enables us to print all our publications within the Department. A staff was also trained in the operation of this printing machine.

The annual reports of the Department for 1960/61, 1961/62 and 1962/63 were received from the Government Printer and have been distributed. Seventeen papers were received for publication during the year and these, together with those already edited, twelve were published and distributed. The Quarterly Research Bulletin was issued regularly throughout the year. Submission of approved papers to Scientific Journals by Research Officers continued at a commendable pace.

Owing to financial stringency, only thirty-two new books were added to the Library, while microfilm copies of journal articles received amounted to forty-six. Loan issued from the Library for the year totalled 579.

The photographic section received 137 requests from the Divisions for its services during the year of which six were for microfilms, seven for photocopies, 41 for duostat copies and the others were for negatives. Forty-five requests were also made for the draughtsman's services.

Publications

The following papers appeared in scientific journals or in departmental memoranda during the year.

Scientific Journals

AFONJA, B. "The validity and usefulness of experiments."

Proc. Agr. Soc. of Nigeria, Vol. 4, 21-26, 1966.

Afonja, B. "The analysis of an experiment with plots of different sizes." Trop. Agric. (In press), 1966.

Afonja, B. & L. Are "Correlation Studies on some chupon main stem characters of virus infected mature cocoa trees."

The Nigerian Agricultural Journal (in press), 1966.

Bredero, Th. J. "Nitrogen, phosphorus and potassium uptake by lowland rice and its relation to yields on some Nigerian alluvial soil." Agronomy Journal Vol. 57: 421-425, 1965.

Bredero, Th. J. "Fertilizer responses in swamp rice (Oryza sativa L.) in Northern Nigeria." Expl. Agric. (1966), 2, pp. 33-43.

Robertson, D. G. "The local lesion reaction for recognizing cowpea varieties immune from and resistant to cowpea yellow mosaic virus." Vol. 55, (No. 8, 923-925) August, 1965.

Sluyters, J. A. F. M. "Milling experiments with parboiled paddy." J. Agric. Sci., Vol. 13 (1965) No. 3 (August).

Departmental memoranda

No. 65. "A preliminary check list of West African Thysanoptera" by B. A. Okwakpam.
66. "Factors involved in parboiling and milling of parboiled rice" by J. A. F. M. Sluyters.
69. "Results of non-replicated farmer's trials in Niger Province, N. Nigeria" by Th. J. Bredero (In press)
71. "Plant introductions.—1963" by J. A. Obi.
72. "Plant introductions—1964" by J. A. Obi.
73. "A list of varieties of rice maintained at the Federal Rice Research Stations" by B. D. A. Beck and J. E. Y. Hardcastle.
75. "Problems of expanding maize production in Nigeria" by P. M. Chinwuba.
76. "List of rubber clones in Nigeria and their distribution on 31st December, 1964" by J. A. Obi.
78. "List of sugarcane varieties in Nigeria and their custodians" by J. A. Obi.
80. "Cowpea production in Nigeria" by U. U. Ebong.
82. A note on the Nigerian rice seed multiplication scheme and descriptions of the currently recommended rice varieties" by B. D. A. Beck, A. G. Bailey, J. E. Y. Hardcastle and J. A. F. M. Sluyters.

REPORT ON THE STATISTICS AND RECORDS DIVISION

Statistics

The statistician continued to give help and advice on the design and analysis of experiments being carried out in the Department. The analysis of the spacing × settweight yam trial with plots of unequal size was completed. Two methods of analysis were advocated of which transformation into per acre basis was one. This trial was also used to obtain Smith's measure of soil heterogeneity. The results are being published elsewhere. Some data from a cassava uniformity trial carried out in 1955/56 were also analysed and the indications were that plot sizes between 192 and 385 sq. ft. seemed to be the optimum. The results of the analysis and the discussion arising are also being published elsewhere.

The statistician continued to give statistical assistance to workers in other Institutions.

A paper entitled "Validity Usefulness of Experiments" was read by the statistician at the Third Annual Conference of the Agricultural Society of Nigeria in July 1965.

Agricultural Records

Experimental summaries were received from all the Regions, though the majority of them came from the North as in the past.

The new Uniform numbering system has now been adopted by almost all the contributors to the centralised data collection.

REPORT ON THE PLANT INTRODUCTION AND POST ENTRY QUARANTINE

Eighty-seven consignments of economic plants from 33 countries involving some 257 plant species were imported for trial during the year under review by government agencies and institutions in the country. Of these, twenty-eight species were imported as vegetative material. These included cocoa, sugar cane, apple, pear, peach, grape vine, rubber, cassava, mango, sisal bulbils and grasses. Introductions which came in the form of seed included coffee, cocoa, maize, tea, oil palm, guar, soya bean, kenaf, barley, groundnut and tobacco. Other seed introductions were citrus, cotton, indigo, rice, sorghum as well as forest tree seeds.

During the year, twenty-nine consignments involving some eighteen plant species were taken into quarantine for observation while 22 species were released after having been certified free from pests and serious plant diseases.

Materials released after quarantine included 22 varieties of cocoa, 94 coffee varieties, 3 grape vine varieties, 32 grass varieties, 6 rice varieties, 11 new rubber clones and 68 sugarcane varieties.

Citrus Experiment

Four rootstock trials—two for sweet orange and one each for lemon and acid lime—and one sweet orange variety trial which were started on Moor Plantation between 1952 and 1955 are still in progress.

Sweet Orange Rootstock Trials

Two separate trials were started in 1952 and 1955 with a view to finding the most suitable rootstocks for sweet oranges. A local selection, Agege I sweet orange, was used as the scion in both trials.

In the 1952 trials, Lake Tangelo and Cleopatra Mandarin have maintained their superiority in yield over the other rootstocks. The mean annual yield marketable fruits in pounds (lbs) per tree over the last ten years was 289.1 for Lake Tangelo and 277.0 for Cleopatra Mandarin. Others were 245.1 for Sampson Tangelo, 161.3 for Agege I sweet orange seedling and 146.2 for Agege I sweet orange rootstock while Sierra Leone Rough Lemon, Trinidad Sour Orange and M. P. Sour Orange came next with 121.9, 19.5 and 16.7 respectively.

In the 1955 trial Rangpur lime is leading four other rootstocks in yield. Over the last seven years, the mean yield of marketable fruits was 122.8 lbs per tree per year for Rangpur Lime. Sampson Tangelo, Agege I sweet orange, Sierra Leone Rough Lemon, and Trinidad Sour Orange came next with 84.6, 79.3, 76.3 and 2.3 per tree per year respectively.

Rootstock Trial for Lemon

This was started in 1955 to find the most suitable rootstock for lemon from eight rootstocks. Lisbon Lemon was used as the scion. Cleopatra Mandarin and Lake Tangelo have maintained their lead over the other stocks in yield. Over the last ten years, the mean annual yield of marketable fruits was 232.7 lbs per tree for Cleopatra Mandarin and 200.1 lbs per tree for Lake Tangelo. Trinidad sour orange, California sour orange and Sampson Tangelo, Agege I sweet orange and Sierra Leone rough lemon followed with 191.9, 176.6, 121.4, 101.2 and 52.7 lbs per tree per year respectively.

Rootstock trial for acid lime: started in 1955

In the trial to find the most suitable rootstock for acid lime, Sierra Leone rough lemon was leading in yield. Over the last eight years, the mean annual yield in lbs. per tree was 37.2 for Sierra Leone rough lemon. Acid lime seedling came next with 27.9 followed by Rangpur lime, Cleopatra Mandarin and Agege I sweet orange with 23.1, 11.5 and 6.6 respectively. Others were Sampson Tangelo with 6.1 and Trinidad sour orange with 3.3.

Sweet Orange Variety Trial: started in 1955

In this trial the performance of two introduced and four selected local sweet oranges are being compared using Cleopatra mandarin as the only stock. Umudike I was leading in the mean yield of marketable fruits over the last seven years with 179.2 lbs per tree per year followed closely by Etinan with 178.4. Meran and Agege I came next with 157.9 and 130.1 lbs. per tree per year respectively while the two introduced varieties, Parson Brown and Ruby Blood, came last with 100.4 and 64.4 lbs. per tree per year respectively.

REPORT ON PLANT QUARANTINE SERVICE

Ibadan

The offices of the Officer-in-charge was moved from Ibadan to Lagos on 3rd December, 1965. Post-entry quarantine and plant introduction was left in Ibadan. Import Permits were issued in Ibadan for plant materials meant for propagation. Inspection of imported plant materials were also done at Ibadan.

Lagos

The base of the plant quarantine activities in Lagos was shifted from Apapa to Ikeja when the Plant Quarantine Headquarters was moved to Lagos. The Plant Importation Control work was continued. Imported Plant Materials were examined at the following places in Lagos.

(*a*)	*Ikeja Airport:*	Passenger Arrivals Hall and Air Freight Shed.
(*b*)	*Apapa:*	Atlantic Commercial Baggage Halls, Parcel Post Depot, and Eleven Freight Sheds.
(*c*)	*Lagos:*	General Post Office, 13 sheds in Lagos Port.

The work at Lagos is hampered by lack of adequately trained staff and lack of Departmental living quarters for the staff, but it is hoped that the situation will improve soon. A gas fired Horsfal incinerator was installed at Ikeja Airport for quick and efficient disposal of condemned plant materials and it is now in use.

Kano

Inspection is carried on at Kano at the Airport and the General Post Office. The distance of the airport from the town and the siting of the Plant Quarantine Office half way between the General Post Office and the Airport caused a good deal of inconvenience in arranging inspection duties. The office was abandoned in August 1965 and the Airport Commandant gave us two rooms at the Airport which are now being used as Kano office. We are still not able to instal a Horsfal incinerator in Kano.

Port-Harcourt

This station was opened in May 1965 to cater for plant materials entering the country via Port-Harcourt Quays. Imported Plant Material is examined at the General Post Office, Sea Passenger Baggage Hall and the four Cargo Sheds at the Wharf. Lack of staff had adverse effect on the staffing of this station. At the end of the period, an Agricultural Assistant is heading the station. This will be corrected as soon as possible.

Calabar

One of the oldest Plant Quarantine stations in Nigeria. It was closed down in August 1962 and re-opened in May 1965. Imported plant material is examined at the Ivy Wharf and the Airport.

Sapele

The Midwest station covering the ports of Koko, Sapele and Warri was closed down on the 15th January, 1966. This was due to the fact that only one consignment of plant material was intercepted in six months. It is proposed to re-open the station as soon as the staffing position of the Plant Quarantine Service improves.

Idiroko

This is the first station opened to cater for border inspection. As most of our neighbouring countries (Cameroun, Chad, Dahomey, and Niger) do not have efficient Plant Quarantine Service, some people prefer to take plant material direct into the neighbouring countries and take them into Nigeria by road. We have intercepted Popcorn from the United States, Fresh Fruits from Queensland, living plants from all over Europe and United States of America at IDIROKO! As soon as our staffing position improves, we shall open more stations between Nigeria and Cameroon, Chad, and Niger.

Kaduna

Inspection site was moved from Kaduna South to the Kaduna General Post Office.

PLANT IMPORTATION

Permits

Nine hundred and fourteen plant import permits were issued during the period at Ibadan and Lagos. This table shows the permit issued in the last four years.

Years	*Number of Permits Issued*
1965-66	914
1964-65	835
1963-64	496
1962-63	432

The Plant Materials for which permits were issued include restricted vegetable seeds, flower seeds, vegetative materials of Ornamentals like Carnations, bulbs and tubers; economic plants like *Hibiscus* spp. (Kenaf), *Gossypium* spp. *Pyrus malus* (Apples), *Vitis vinifera*, etc.

Inspection

The total number of consignments of Plant materials examined on importation at all stations was six thousand, six hundred and seventy-one (6671). Intercepted items included Maize, Sunflower, tobacco, Cacao seeds, Sugar-cane, Ginger tubers, fruit trees and grape vine plants.

Plant Exportation

This aspect of our work (including issuing of Phytosanitary Certificates) was transferred to the Chairman of the Plant Quarantine Committee as from the 1st of January, 1966.

APPENDIX I

AN ANALYSIS OF THE ESTABLISHMENT 1965-66

The authorised establishment of senior staff at the beginning of the year, and the actual strength at 31st March, 1966, are given below.

Administrative and Professional	*Establishment*	*Filled*	*Vacant*
Director of Agricultural Research	1	1	—
Deputy Director of Agricultural Research	1	1	—
Principal Research Officers	5	5	—
Senior Research Officers	8	5	3
Research Officers	38	12	26
Librarian	1	—	1
Total Administration and Professional Staff	54	24	30

Executive (Technical) Higher Technical Staff	*Establishment*	*Filled*	*Vacant*
Senior Technical Officer	1	—	1
Higher Technical Officers	3	2	1
Technical Officers	16	15	1
Assistant Technical Officers	19	5	14
Senior Laboratory Technologists	1	—	1
Higher Laboratory Technologists	3	1	2
Laboratory Technologists	6	2	4
Asst. Laboratory Technologists	11	7	4
Station Managers	(2)	(2)	(drawn from (H.T.O. & T.O.)
Mechanical Demonstrator	2	1	1
Total Executive (Technical) Higher Technical Staff	62	33	29

Executive (Administration)	*Establishment*	*Filled*	*Vacant*
Senior Accountant	1	1	—
Higher Executive Officer	1	1	(Ag.) —
Executive Officer (Gen. Duties)	1	1	—
Executive Officer (Accounts)	1	1	—
Assistant Executive Officer (G.D.)	2	1	1
Asst. Executive Officer (Accounts)	4	2	2
Library Officer	1	1	—
Personal Secretary	1	1	—
Total Executive Staff	12	9	3
Grand Total Senior Staff	128	66	62

The authorised establishment of junior staff at the beginning of the year, and the actual strength at 31st March, 1966, are given below:

Clerical	*Establishment*	*Filled*	*Vacant*
Chief Clerk	1	1	—
Assistant Chief Clerks	2	2	—
First Class Clerks	11	11	—
Second Class Clerks	25	21	4
Library Clerks	2	2	—
Stenographers Grades I and II	2	2	—
Store-keeper Grade I	1	1	—
Store-keepers Grades II and III	7	6	1
	51	46	5

Technical	*Establishment*	*Filled*	*Vacant*
Senior Agricultural Asst. Grade I	1	—	1
Senior Agric. Assistants Grade II	4	6*	—
1st Class Agric. Lab. Technicians	2	—	2
Agricultural Assistants Grade I	18	11	7
Agricultural Assistants Grades II & III	85	68	17
2nd and 3rd Class Agric. Lab. Technicians	19	16	3
Photographic Asst. Grade I	1	1	—
Draughtsman Grade II	1	1	—
Total Technical Staff	131	103*	30

Minor Technical and Sub-Clerical			
Senior Field Overseers	8	3	5
Field Overseers Grades I & II	68	63	5
Artisans	13	13	—
Senior Driver/Mechanic	1	1	—
Driver Mechanics	12	12	—
Clerical Assistants	11	9	2
Typists	17	17	—
Meteorological Recorder	1	1	—
Senior Laboratory Attendant	1	1	—
Laboratory Attendants	12	12	—
Telephone Attendants	3	—	—
Stores Assistants	4	3	1
Stores Attendants	2	2	—
Head Messenger	1	1	—
Messengers	18	17	1
Duplicating Machine Operator	1	—	1
Total Minor Technical and Sub-Clerical Staff	173	158	15
Grand Total Junior Staff	355	307*	50

Progress of Nigerianisation as at 31st March, 1966

Type of Post	*Nigerian*	*Expatriate* (P)	(C)	*Vacant*	*Total*
Administrative and Professional ..	18	3	3	30	54
Executive (Technical)	28	—	1	33	62
Executive (Administration)	8	—	1	3	12
Technical	103*	—	—	30	131
Minor Technical and Sub-Clerical ..	158	—	—	15	173
Clerical	46	—	—	5	51
Total	361	3	5	116	483

(P) = Pensionable; (C) = Contract Terms

APPENDIX II

ANNUAL REPORT ON METEOROLOGICAL DATA 1965

METEOROLOGICAL STATION—MOOR PLANTATION

(Latitude 7° 23' N: Longitude 3° 51' E: Altitude 574 feet)

Month	*Rainfall in inches 10.00 a.m.*	*10 Years Average in inches*	*No. of Wet Days*	*Cumulative Total in inches*	*Cumulative Total in inches*	*Mean Relative humidity %*	*Max. Temperature 10.00 a.m.*	*Minimum Temperature 10.00 a.m.*	*Mean Daily Duration of Sunshine in hours*
January ...	0.56	0.16	1	0.56	81.2	92.0	70.5	81.3	6.7
February ...	1.10	0.84	5	1.66	81.3	94.5	70.4	82.5	7.2
March ...	4.25	3.68	6	5.91	80.6	95.0	71.9	83.5	6.7
April ...	3.39	4.84	9	9.30	80.9	91.3	70.5	80.9	6.1
May ...	10.72	6.06	15	20.02	84.0	89.6	69.4	79.5	6.6
June ...	13.38	8.55	17	33.40	85.3	87.2	69.8	78.5	5.6
July ...	12.63	6.49	23	46.03	87.9	83.7	69.5	76.6	2.8
August ...	10.59	4.51	20	56.62	90.1	82.7	69.2	76.0	2.5
September ...	7.84	6.23	15	64.46	87.2	85.2	69.0	77.1	3.5
October ...	3.77	7.48	16	68.23	83.1	89.6	70.9	80.3	5.9
November ...	0.00	2.29	0	68.23	81.9	91.5	73.0	82.3	7.2
December ...	0.00	0.38	0	68.23	77.3	92.0	69.0	80.5	7.2
TOTAL ...	68.23	51.51	127		1000.8	1074.3	843.1	959.0	68.0
AVERAGE ...	5.68	4.29	10.58		83.4	89.52	70.26	79.91	5.67

APPENDIX III

ANNUAL REPORT ON METEOROLOGICAL DATA 1965

METEOROLOGICAL STATION—BADEGGI

(Latitude 9° 07'N: Longitude 6° 08'E: Altitude 225 feet)

Month	*Rainfall in inches 10.00 a.m.*	*10 Years Average in inches*	*No. of Wet Days*	*Cumulative Total in inches*	*Mean Relative humidity %*	*Max. Temp. 10.00 a.m.*	*Minimum temperature 10.00 a.m.*	*Mean Temperature 10.00 a.m.*	*Mean Daily Duration of Sunshine in hours*
January ...	0.16	0.49	1	10.65	71	93	66.2	79.6	8.5
February ...	1.98	0.27	1	2.90	71	95	69.2	82.1	9.3
March ...	0.92	1.00	2	4.82	64	98	69.7	83.8	7.7
April ...	0.53	2.29	3	7.64	66	98	73.6	85.8	7.2
May	4.77	5.12	8	17.53	72	96	75.6	85.8	8.09
June	6.53	7.34	13	31.40	79	89	73.8	81.4	7.36
July ...	5.70	7.91	16	45.01	82	87	73.3	80.1	5.58
August ...	8.68	7.06	20	60.75	87	85	72.6	78.8	3.91
September ...	9.64	9.82	16	80.03	83	87	72.6	79.8	6.49
October ...	2.93	4.05	9	87.01	80	90	73.3	81.6	8.80
November ...	0.00	—	—	—	60	93	66.9	79.9	9.10
December ...	0.00	—	—	—	55	92	60.9	76.4	8.6
TOTAL ...	41.84	45.35	89		870	1103	84.77	975.1	90.63
AVERAGE ...	3.48	3.78	7.4		73.0	92.0	70.6	81.3	55.7

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